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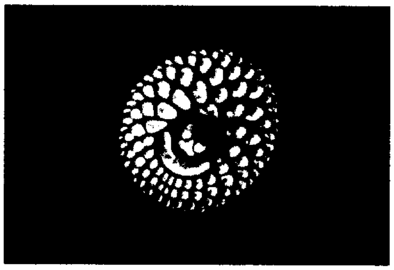
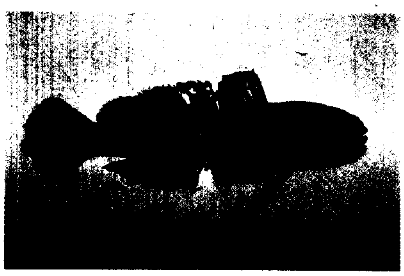
Regulatory Evaluation

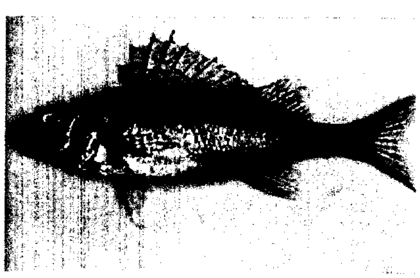
Mandatory Ballast Water Management Program for U.S. Waters

Notice of Proposed Rulemaking
USCG-2003-14273





Prepared by:
Standards Evaluation & Analysis Division (G-MSR-1)
U.S. Coast Guard Headquarters
Washington, DC



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Acronyms

BWM	Ballast Water Management
CFR	Code of Federal Regulations
DWT	Deadweight Ton
EEZ	Exclusive Economic Zone
FR	*Federal Register*
IMO	International Maritime Organization
IRFA	Initial Regulatory Flexibility Analysis
MARAD	U.S. Maritime Administration
MEPC	Marine Environmental Protection Committee
MSIS	Marine Safety Information System
MSMS	Marine Safety Management System
NAICS	North American Industrial Classification System
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990
NBIC	National Ballast Water Information Clearinghouse
NIS	Nonindigenous Species
NISA	National Invasive Species Act
NVMC	National Vessel Movement Center
OMB	Office of Management and Budget
PV	Present Value
RFA	Regulatory Flexibility Act
SERC	Smithsonian Environmental Research Center
TEU	Twenty-foot Equivalent Unit

Photography credits for front cover:

Zebra mussels on native clam on beach.
Fred Synder
Ohio Sea Grant

Sea lamprey mouth.
GLSGN Exotic Species Library
Great Lakes Sea Grant Network Exotic Species Graphics Library

Male round goby.
David Jude
Center for Great Lakes Aquatic Sciences (CGLAS)

Purple loosestrife plants getting a foot hold in a newly formed river delta sand bar.
Michigan Sea Grant

Eurasian ruffe.
Gary Chowlek
National Biological Service

Contents

Appendices

A	Comparison of Ballast Water Capacity Estimates from Various Sources
B	Probabilities of Exchange Based on Sea States
C	Calculations of Cost
D	Calculations of Benefit
E	Initial Regulatory Flexibility Act Analysis

Tables and Figures

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Executive Summary

This Regulatory Evaluation identifies the vessel population affected by the proposed rule and provides cost and benefit models for the principal option of ballast water management (BWM) provided for under the rule—ballast water exchange. BWM is applicable for any vessel with ballast water entering U.S. waters from outside the U.S. Exclusive Economic Zone (EEZ). The vessel population was categorized by vessel type under the assumption that vessels in different cargo services and of different sizes likely manage ballast water in different ways. We estimate that approximately 7,420 vessels will be affected and approximately 11,500 ballast water exchanges will be performed annually. Annual costs totaled approximately $15.8 million. The 10-year present value cost for this rule is $116.7 million.

The unintentional introduction of nonindigenous species (NIS) into the waters of the United States via the discharge of ships' ballast water is posing a serious risk to coastal facilities and global biodiversity. The benefit calculation expanded on the analysis conducted for costs by focusing on the probability of viable organisms being introduced into U.S. waters through ballast discharge, both before the proposed rule and following the implementation of mandatory BWM. The calculations indicated the proposed rule may result in avoiding approximately 10 inoculations (injections of organisms from ballast water into an ecosystem) that result in invasions for each year the rule is in effect. Due to the inherent uncertainly in these estimates and the lack of reliable information on the costs of invasions, we did not attempt to monetize the damages attributable to avoided inoculation.

The Initial Regulatory Flexibility Analysis identified 21 U.S.-flagged vessels owned by 10 small businesses that would be affected by the proposed rule. This rule will not have a significant effect on a substantial number of small entities.

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1. Introduction

The unintentional introduction of nonindigenous species (NIS) into the waters of the United States via the discharge of ships' ballast water is posing a serious risk to coastal facilities and global biodiversity. To comply with the National Invasive Species Act of 1996 (NISA), the Coast Guard proposes mandatory ballast water management (BWM) practices for all vessels bound for ports or places within the United States and for vessels entering waters of the United States. This proposed rulemaking would increase the Coast Guard's ability to protect U.S. waters against the introduction of NIS via ballast water discharges.

Ballast serves an essential role in safe, efficient, and successful operation of vessels, and water taken into a vessel via onboard pumps is the most common form of modern ballast. The intake and discharge of ballast water is conducted for a variety of reasons including controlling vessel trim, draft, and stability. Ballast water functions as a surrogate load in place of cargo, fuel, usable water, and personnel. Modern cargo vessels can carry enormous volumes of ballast water (tens of millions of gallons), any portion of which may be discharged for various reasons along any part of a journey [14, 66]. The increased size and ballast water capacity of modern vessels has increased the number of individual organisms transported and released around the world. In U.S. waters, the total amount of ballast water discharge is greater than 21 billion gallons per year, more than 2 million gallons per hour [14, 66].

As ballast water is taken aboard a vessel, organisms living in the ballast water may survive in the ballast tanks. Virtually all aquatic species—from microscopic viruses and bacteria to zooplankton, fish, and plants—can be entrained and transported in ballast water [34]. This can include organisms that reside in the sediments, water column, water surface, or any combination. Organisms may be entrained during adult, juvenile, or even larval stages. In addition, all symbionts, parasites, and pathogens associated with an organism can be entrained as well [50]. One report found that the ballast water of 159 ships contained all major and most minor phyla [15]. A study of the ballast water of 169 ships arriving in Prince William Sound, Alaska, found an average of 12,637 total organisms per vessel [32].

More than 10,000 different species may be transported in ballast water around the globe on any given day [11, 12]. As the vessel journeys to a new port, organisms in the ballast tanks are transported as well. During ballast water discharge, these organisms may be released into receiving waters of a new ecosystem. The large volume of modern ballast tanks means that although mortality rates may be high during transport, a large number of viable individuals may still be released during ballast water discharge.

Aquatic species have been transported to and from U.S. waters and around the globe via the shipping trade for hundreds of years. This does not imply, however, that all potential species introductions have already occurred. As shipping routes and technologies advance and as conditions within ecosystems change, the opportunities for species to infiltrate new areas change. The size, speed, and travel distance of modern vessels has contributed to increasing rates of NIS introductions [61].

New trade routes can develop as new commodities become available or as political and economic conditions open ports to international commerce [13, 14]. As these new donor regions become available, a new suite of NIS may be imported to U.S. waters. Even along established routes, changes in the environmental characteristics or organism populations of donor or recipient regions may provide new opportunities for NIS introductions [13, 14]. Additionally, once a NIS is introduced to an area and survives, that area then becomes a potential donor region.

The shipping industry has clear economic incentives to decrease voyage times, and new technologies have focused on creating faster vessels. As transport time decreases, the survival rate and health of biota in ballast water tanks increases, leading to a greater potential for the introduction of viable NIS [14, 22]. Increased speed may also allow a vessel to visit more ports in a shorter amount of time, increasing the number and rate of potentially affected areas.

Mandatory Ballast Water Management

This proposed rulemaking will revise 33 CFR part 151 to implement the requirements of NISA. Specifically, subpart D of 33 CFR 151 will be revised to require a mandatory BWM program for all vessels equipped with ballast water tanks entering U.S. waters. For the purposes of this rulemaking, U.S. waters include the waters of all 50 States, the District of Columbia, Puerto Rico, Guam, American Samoa, the U.S. Virgin Islands, and the Trust Territories of the Pacific Islands. The mandatory BWM requirements for vessels entering into the Great Lakes and Hudson River from outside the Exclusive Economic Zone (EEZ) will remain unchanged. The current rulemaking will require all vessels carrying ballast water into U.S. waters after operating beyond the EEZ to employ at least one of the following ballast water management practices—

- Prior to discharging ballast water in U.S. waters, perform complete ballast water exchange in an area no less than 200 nautical miles from any shore

- Retain ballast water on board the vessel

- Use an alternative environmentally sound method of ballast water management that has been approved by the Coast Guard before the vessel begins its voyage

- Discharge ballast water to an approved reception facility

A vessel will not be required to deviate from its voyage or delay its voyage in order to conduct a ballast water exchange. A vessel voyage that cannot practicably meet the above requirements because its distance from shore never exceeds 200 miles will not be prohibited from discharging its ballast water in areas other than the Great Lakes and Hudson River. In addition, if safety concerns prevent the vessel from conducting a mid-ocean ballast water exchange, it will also not be prohibited from discharging ballast water in the areas other than the Great Lakes and Hudson River. The vessel must discharge only the amount of ballast water operationally necessary and make an entry in its ballast water records supporting its claim that it could not comply with the regulatory requirements. These ballast water records must be made available to the local U.S. Coast Guard Captain of the Port upon request.

The Coast Guard would not expect, for example, a passenger vessel traveling from the Bahamas to Fort Lauderdale, Florida, (approximately 200 miles) to travel an additional 200 miles and delay its voyage by 24 hours to conduct a ballast water exchange. This passenger vessel would discharge the necessary ballast water at port and make a ballast water report form entry stating the reasons for not complying with the requirements.

Those vessels choosing to retain ballast water on board may need to transfer ballast water internally within the vessel to satisfy stability requirements imposed by cargo operations. At this time, there are no approved onboard treatment methods for ballast water; therefore, this alternative is not yet available. In addition, there are limited facilities available for on-shore processing of ballast water and none are approved for the removal of NIS. As a result, the subject of this analysis is ballast water exchange.

The Coast Guard recognizes that there are two currently feasible methods of conducting an exchange—

- **Sequential (empty/refill) exchange**—each tank or a pair of tanks are pumped down to the point where the pumps lose suction, and then the tank is pumped back up to the original levels.

- **Flow-through exchange**—mid-ocean water is pumped into a full tank while the existing coastal or fresh water is pumped or pushed out through another opening.

Finally, this rule will require all applicable vessels to maintain a ballast water management plan onboard the vessel.

Statutory Authority

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) [Pub. L. 101-6461], enacted by Congress on November 29, 1990, established the Coast Guard's regulatory jurisdiction over BWM. To fulfill the directives of NANPCA, the Coast Guard published a final rule on April 8, 1993, entitled "Ballast Water Management for Vessels Entering the Great Lakes" [58 FR 18330]. This rulemaking established mandatory procedures for the Great Lakes in 33 CFR part 151, subpart C.

A subsequent final rule entitled, "Ballast Water Management for Vessels Entering the Hudson River," was published on December 30, 1994, [59 FR 67632], which amended 33 CFR part 151 to extend the ballast water management requirements into portions of the Hudson River.

NISA [Pub. L. 104-3321] enacted by Congress on October 26, 1996, reauthorized and amended NANCPA. NISA reemphasized the significant role of ships' ballast water in the introduction and spread of NIS and mandated the development of a voluntary, national BWM program. The Coast Guard finalized this voluntary program in the rule entitled, "Implementation of the National Invasive Species Act of 1996 (NISA)" [66 FR 5838], which was published on November 21, 2001. In order to impose penalty provisions under NISA for non-submission of Ballast Water Management Reports, the Coast Guard published on January 6, 2003 [6859 FR 523], "Penalties for Non-submission of Ballast Water Management Reports" notice of proposed rulemaking. This rulemaking also proposes widening the applicability of the reporting and recordkeeping requirements to all vessels bound for ports or places within the United States, with minor exceptions. Public vessels remain exempt in the rule, as do tankers engaged in coastwise trade.

In NISA, Congress also instructed the Secretary of Transportation (Secretary) to submit a Report to Congress evaluating the effectiveness of the voluntary BWM program. Congress anticipated that the Secretary might determine that either compliance with the voluntary guidelines was inadequate, or the rate of reporting was too low to allow for a valid assessment of compliance. In either case, Congress stipulated the development of additional regulations to make the voluntary guidelines a mandatory BWM program. The Secretary's report to Congress, signed June 3, 2001, concluded that compliance with the voluntary guidelines, found in 33 CFR part 151, subpart D, was insufficient to allow for an accurate assessment of the voluntary BWM regime. Accordingly, the Secretary stated his intention to make the voluntary BWM requirements mandatory [63].

To further advance the development of a national BWM program, the Coast Guard published three notices. The first notice, entitled "Potential Approaches to Setting Ballast Water Treatment Standards" [66 FR 218071], published May 1, 2001, requested comments on approaches to setting, implementing, and enforcing ballast water standards. It was followed by an advanced notice of proposed rulemaking with the same title, published March 4, 2002 [67 FR 9632]. The third notice, entitled "Approval for Experimental Shipboard Installations of Ballast Water Treatment Systems" [66 FR 282131], published on May 22, 2001, requested comments on a possible means of providing incentives for ship owners to assist in the development and testing of ballast water treatment technologies.

International Efforts in Ballast Water Management

The International Maritime Organization (IMO), through its Marine Environmental Protection Committee (MEPC), adopted voluntary guidance for preventing the introduction of unwanted aquatic organisms and pathogens from ships' ballast water and sediment discharges at its 31st session in 1991. In 1993, the IMO Assembly adopted these guidelines by resolution A.774(18). The IMO Assembly in 1997 adopted the Guidelines for the Control and Management of Ships Ballast Water by Resolution A.868(20). The MEPC has been working to develop a technical performance standard for ballast water treatment and is working toward signing a convention in 2003.

Individual nations have developed legislation to address aquatic NIS. Canada, Israel, Chile, Panama, Australia, New Zealand, and Argentina have enacted national legislation to limit the introduction of NIS through BWM techniques. In addition, there are two site-specific mandatory programs to protect particular port areas, one in Scotland and one in Argentina.

Mandatory Regimes

Australia—effective July 1, 2001, vessels entering Australian waters must manage their ballast water in accordance with Australia Quarantine and Inspection Service requirements and are prohibited from discharging high-risk ballast water in Australian ports or waters [5]. Ballasting operations must be conducted in accordance with IMO Guidelines. Exchange methods include flow-through, sequential, and dilution methods. The criteria for exchange are outside 12 nautical miles, a 95 percent volumetric exchange, and water exceeding 200 meters in depth [5]. All vessels are required to submit a Quarantine Pre-Arrival Report prior to entering Australian waters, complete 2 forms for the Inspection Service (a discharge log and exchange log), and submit to an inspection if required. Verification is done by comparing submitted documentation with onboard engineering and deck logs. Sediments may not be discharged in Australian waters and written prior approvals for tank stripping operations must be obtained [5].

Israel—effective August 15, 1994, all vessels are required to exchange all ballast that has not been taken on in the open ocean. Exchange must take place beyond any continental shelf or fresh-current effect, and ships bound for Mediterranean ports must exchange in the Atlantic when practicable. The only alternative allowed is retention on board, and no exceptions are listed for the requirement. A ballast water reporting form must also be submitted to the Ministry of Transport [39].

Chile—effective August 10, 1995, applicable to all ships coming from abroad with ballast water aboard, ballast water is required to be exchanged in deep water. Recordkeeping is required by the vessel in bridge and engine room logbooks, showing the geographical coordinates of the location of the exchange, amount replaced, and what percentage of total ballast capacity it represents. One alternative is specified: the addition of 100 grams of powdered sodium hypochlorite or 14 grams of powdered calcium hypochlorite per tonne of ballast water, ensuring thorough mixing [36]. There must be a delay of 24 hours between the chemical addition and the beginning of ballast discharge operations [17].

New Zealand—enacted legislation effective first as a voluntary program in 1996 and made mandatory on April 30, 1998. It is applicable to all ships entering New Zealand territorial waters carrying ballast loaded within the territorial water of another country. These requirements require a mid-ocean exchange of ballast water applicable to ballast water loaded in another country and due for discharge in New Zealand. Alternatives acceptable include the use of fresh water in ballast tanks, with fresh water defined as less than 2.5 percent sodium chloride. The requirements also permit the use of approved on-shore treatment facilities, approved in-tank treatments, or discharge into an approved low-risk zone. No facilities, treatments, or discharge zones have yet been approved [37]. A ballast water reporting form is required to be submitted that documents the location and volume of ballast water loaded in other ports, the location, volume, method, and duration of exchange at sea, and the location, volume, and date of discharge of ballast water in New Zealand [51].

Panama—ships are prohibited from discharging ballast water in the Panama Canal [3].

Scapa Flow, Scotland, Orkney Islands, Flotta Terminal—beginning prior to 1998, a site-specific requirement for all ships except liquefied gas carriers to discharge ballast to the shore reception facility at Flotta Terminal. Ballast from liquefied gas carriers may be discharged into Scapa Flow if it has been taken on board within 24 hours and at least 12 miles from shore. The master must provide the harbor authorities with documentation of ballasting operations and their location. Ballast samples may be taken by authorities to assess suitability for discharge [38].

Buenos Aires, Argentina—another site-specific requirement in place since 1990, applicable to ships arriving in Buenos Aires from areas where cholera is endemic. Coastal areas are designated where discharge of ballast water is prohibited. An in-tank treatment is permitted that adds chlorine to ballast water through air pipes. Sampling is conducted on a random basis and no report is required to be submitted [21].

Voluntary Guidelines

Canada—implemented voluntary guidelines for the exchange of ballast water prior to ships entering the Great Lakes bound for ports west of 63 degrees West longitude. The guidelines became effective on May 1, 1989. The guidelines request a report of ballast water uptake and exchange and that ballast water be exchanged as far from land as possible and in water depths exceeding 2,000 meters. For vessels not leaving the North American Continental Shelf, exchanges are encouraged in Laurentian waters southeast of 63 West longitude. The guidelines require the ballast pump run during discharge until the pump loses suction. The master of the vessel is requested to fill out a Ballast Water Exchange Report, and verification of exchange may be completed by inspectors who take samples of ballast waters from the vessel [24].

State Efforts in Ballast Water Management

Within the United States, several coastal states have enacted legislation that prescribes ballast water management to protect coastal waters from the introduction of pollutants, to include NIS.

Mandatory Regimes

Alaska—Alaska Statute 46.03.750 prohibits the discharge of ballast water from the cargo tanks of petroleum tank vessels [2]. Although appearing in summary reports concerning reducing the risk of invasive species invasion, the purpose of this requirement is to prevent oil-contaminated water from being discharged into the environment.

California—California requires BWM for all vessels with ballast tanks. Vessels must either treat, exchange outside 200 nautical miles in water 2,000 meters deep, retain on board, or discharge to an approved facility. The National Ballast Information Clearinghouse (NBIC) form is the required reporting instrument and reporting must take place before departure from the first California port [9].

Oregon—for vessels over 300 gross tons, Oregon requires ballast water to be exchanged prior to entering state waters, either in an open-ocean exchange 200 nautical miles from shore and at a depth of 2,000 meters, or in a "coastal exchange" defined for vessels traveling along the North American coast as either an exchange south of 40 degrees North latitude for northbound vessels or north of 50 degrees North latitude for vessels traveling south to enter state waters. Reporting is required 24 hours prior to entering state waters and verification of compliance relies on tests conducted by the Coast Guard [53]. Effective date of Oregon regulation is January 1, 2002.

Washington—has issued requirements for a mandatory BWM program that imposes either adequate exchange of ballast water prior to entering state waters or treatment of the discharged ballast water to an interim standard. Although the regulation is not scheduled to be effective until July 1, 2004, the interim standard is specified as removal or inactivation of 95 percent of zooplankton organisms and 99 percent of phytoplankton organisms and bacteria [55]. There is currently a mandatory reporting requirement in place only for vessels discharging ballast water into state waters [56].

Voluntary Regimes

Maryland—although reporting is mandatory, the state voluntary BWM guidelines mirror existing Coast Guard regulations, including 200 nautical miles offshore and 2,000 meters water depth [47]. The state also suggests use of the plan outlines in the IMO Resolution, A.868

Guidelines for Control and Management of Ships Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens, adopted in November, 1997.

Virginia—again, reporting is mandatory, prior to departing state waters or not more than 72 hours after discharge. The state adopts the federal program as voluntary guidelines [68].

Regulatory Evaluation

This rule is not economically significant (cost of the rule does not exceed $100 million in any one year); it is, however a "significant regulatory action" under Executive Order 12866 and has been reviewed by the Office of Management and Budget (OMB).

This regulatory evaluation presents the analysis of cost and benefit of the proposed rule for mandatory BWM. Since the rule is expected to go into effect January 2004, the analysis covers the period 2003 through 2013. All costs and benefits are discounted at 7 percent in 2003 dollars (7 percent is the discount rate preferred by the OMB for cost-benefit analysis). The period of 10 years was selected because of the continuing work to develop ballast water treatment standards and treatment technology. Early studies of the effectiveness of ballast water exchange in reducing the risk of ballast-mediated bioinvasions focused on identifying the amount of original ballast water that remained following exchange. One result estimated only 5 percent of the original ballast water remained in a bulk carrier following mid-ocean flow-through exchange [58]. Subsequent studies, however, showed that although little of the original ballast water was retained following exchange, much of the entrained phyto- and zooplankton were retained. In a study of older vessels, the efficacy of ballast water exchange in removing diatoms and dinoflagellates was as low as 48 percent [20]. For these reasons, we anticipate ballast water exchange will be replaced by treatment technologies that allow fewer organisms to be introduced to U.S. waters via ballast water discharge.

Chapter 2 presents the cost analysis, while Chapter 3 presents the benefit analysis. Chapter 4 contains an Initial Regulatory Flexibility Act Analysis (IRFA).

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2. Cost Analysis

In this analysis, we developed the total cost of the proposed rule for the affected vessel population. The number of vessels that will be affected was determined using several data sets. Unit costs per cubic meter of ballast water exchanged were based on data from vendors and U.S. government published information. Vessel arrivals into U.S. ports were from data covering 1999 and 2000. Data from 2001 were excluded because the events of September 11 were assumed to have affected shipping traffic to U.S. ports to the extent that the year would not be representative of normal shipping volumes.

Overview of Data Needs and Sources

Calculating the costs of BWM proved challenging. We believe we captured the order of magnitude of the cost of BWM; however, we were unable to calculate the precise cost of this rulemaking with a high degree of certainty. Estimating the annual cost of conducting ballast water exchanges presented a variety of obstacles. The complex nature of shipping, erratic routing in many services, and varying capacities of ballast water by ship type and size forced us to make many assumptions to allow a tractable analysis. We believe that, in the aggregate, we have produced a likely outcome. On a ship-by-ship basis, we are less likely to have captured accurate estimates because of the variance and uncertainty present at the individual ship level. In addition to providing our calculations, this chapter also discusses these assumptions in detail and provides our rationale for the analysis.

Further complicating our calculations were the options for BWM provided in the proposed rule. Vessel operators may select any of these options to meet the requirements of the rulemaking—

- Conduct ballast water exchange
- Maintain ballast on board the vessel
- Discharge ballast water to an onshore facility
- Treat ballast water with approved, onboard technology

This analysis focuses on ballast water exchange as the primary cost of this rule. Operators may choose to internally maintain ballast water onboard rather than conducting exchange. We do not have a good estimate, however, of how many vessel operators will choose this option in lieu of exchange. Additionally, the amount of pumping required to internally manage ballast water may be similar to an exchange; thus, the costs are likely comparable. Currently, there are few onshore facilities that receive and process ballast water. This is not currently a feasible option, therefore, for most ships making ports of call in the United States. Finally, we are unable to estimate how many vessels will have advanced technology installed to treat ballast water before release into U.S. ports. We believe few vessels will employ advanced technology in response to this rulemaking, as there are few technologies available, none are yet approved by the U.S. Coast Guard, and none are economically feasible to a wide range of ships. The option of treatment technologies remains an important future regulatory option as demonstration projects are currently investigating new technology possibilities and as the criteria to measure successful BWM moves to a discharge standard. If options for onboard technology or onshore treatment become available prior to the proposed rule becoming final, amendments to this regulatory analysis may be made at that time.

To estimate the annual cost of the analysis, we required many different pieces of information from many different sources. These are described below.

Number of arrivals into U.S. ports—to determine which ships, both U.S.- and foreign-flagged, enter the United States annually and might require an exchange before entering. We used data from the Coast Guard's Marine Safety Management System (MSMS) for 1999 and 2000. From these data, we determined that there are about 34,700 arrivals annually from 7,420 ships that could conduct a ballast exchange.

Last port of call for annual arrivals—to determine how many of the annual arrivals in U.S. ports would require a ballast water exchange before entering port and to determine vessel "tracks," or distinct routes that vessels typically transit. We used information from databases at the Coast Guard's National Vessel Movement Center (NVMC) for 2002. Prior to 2002, the Coast Guard did not systematically record the last port of call, thus we could not use the MSMS data described above for annual arrivals. From the NVMC data, we identified 13 tracks that vessels transit regularly.

Ship service and capacity or size—to determine what kind of exchange (sequential or flow-through) would be required and to determine whether an exchange would be safe under prevalent sea conditions. We used MSMS, which provided the IMO number (a unique vessel identifier). The IMO number was then cross-referenced with data from *Lloyd's Register of Shipping 2002* to determine the service. From these data, we identified nine distinct types of cargo or passenger service that could feasibly conduct ballast exchange. These services were further delineated by twenty-foot equivalent units (TEU) (container ships) or deadweight tons (DWT) (all other services) into 20 total types of ships that would be subject to this rulemaking. There are no published data that indicate which type of exchange is best suited to an individual vessel. As a result, we made the assumption that vessels in liner services will conduct sequential exchanges, while vessels in bulk services will conduct flow-through exchanges.

Average total ballast capacity (in m^3)—to determine the average volumes of ballast water that would need to be exchanged. We used data from Ballast Water Reporting Forms maintained by the National Ballast Water Information Clearinghouse (NBIC) and administered by the Smithsonian Environmental Research Center (SERC). This was corroborated with other, more limited, data from *Lloyd's Register* and ballast water literature (see Appendix A). We determined that ballast water capacity ranged from 3,700 m^3 (small container ships) to 93,000 m^3 (large tankers). It should be noted that the cost of exchange of the entire ballast capacity of each vessel was used. We used this estimate because it is the upper bound of ballast exchange costs, and there are no complete records available for the amount of ballast discharged per vessel visit in U.S. waters.

Vessel ballast pump capacity (in m^3/hour)—to determine the ballast water system maintenance cost as a function of total capital cost for a ballast water system. We used data from personal communications (January 2003) with the U.S. Maritime Administration (MARAD). We determined that pump capacity ranged from 75 m^3/hour (small container ships) to 2,500 m^3/hour (large tankers). Pump cost information came from personal communications with members of industry.

Wave-height limits—to determine where and how often (expressed as a probability) vessels could safely conduct ballast water exchanges. We used data from *Lloyd's Register* Ballast Water Management Services and the American Bureau of Shipping to make assumptions concerning maximum sea states allowable for exchange for all vessel types (see Appendix B). We then obtained summary statistical wave height data for likely vessels transit tracks [31]. We determined that bulkers, tankers, and gas carriers will be able to conduct ballast exchange about 70 percent of the time, depending on where the vessel transits. All other services will be able to conduct an exchange about 95 percent of the time, again depending on where the vessel transits.

The cost of ballast water exchange includes the cost of the fuel for running the ballast water pumps as well as the cost of maintaining the ballast pumps, accounting for the extra run-time associated with mid-ocean exchanges. It was assumed that no new equipment would be installed to comply with the rule, and, though some additional demands would be made on the ship's crew, no additional personnel would be added to the vessel to conduct BWM. Finally, additional recordkeeping will be required through a BWM plan, to be kept on board each vessel. This provision was also part of the voluntary program, and many vessels already maintain BWM plans, though we do not know how many. We account, therefore, for the full cost of a mandatory BWM plan in this evaluation.

Using this information, we were able to estimate the annual cost of ballast water exchange. While this estimate carries some uncertainty, we believe it is a good estimate of the magnitude of costs industry can expect to incur as a result of this rulemaking.

Maritime Transportation

The ocean transportation industry is a diverse group of businesses. The dominant ship types of the deep-sea cargo-carrying fleet are general cargo, tankers, and dry-bulk carriers. Added to this list are specialized vessels carrying commodities ranging from flammable gases to vehicles to passengers. Ocean shipping operations fall into two broad categories: tramp shipping and liner service.

Tramp shipping provides convenient, timely, and economical transportation to the broad variety of raw materials and finished goods needed by a global economy. Vessels contract for particular cargoes on routes that vary from voyage to voyage. Tramp ships provide excess capacity along established trade routes and low-cost transportation for agricultural goods and many natural (crude oil, timber, ores, mineral products) and manufactured (petroleum, cement, steel, fertilizers) raw materials. In this sector, it is common for all of the cargo on board to belong to a single owner and to be loaded and offloaded at individual ports. Tankers and dry bulk carriers are typical vessel types.

Liner-service vessels, in contrast, operate on set routes and on fixed schedules. They commonly carry a variety of cargoes, the majority of which are finished goods and cargoes belonging to many different cargo owners. In this sector service is key, and the shipping company typically has a large traffic department responsible for generating the cargo business to fill the company ships. General cargo and container ships are typical vessel types in this sector.

The importance of understanding the differences in these two sectors of ocean transportation lies in the impact their distinct operation methods have on ballast water discharged into U.S. waters. Ballast is pumped aboard, around, and discharged from vessels to achieve acceptable conditions of stability, list, and trim. Ballast quantities change as a result of cargo operations. Vessels in tramp service, moving shipload lots of cargo from one port to another, travel with a minimum of ballast and a maximum of cargo in order to maximize revenue generated by the voyage. They then frequently travel to a different port, in ballast and without cargo, to load another cargo bound for yet a different port. Thus, these vessels routinely discharge the entirety of their onboard ballast at the port in which they load cargo. Liner-service vessels, by contrast, travel between ports with a combination of cargo and ballast, pumping comparatively small volumes of ballast in response to changes in cargo distribution among various cargo holds. It is unlikely all ballast water in a particular tank would be from a single port, let alone all the ballast water aboard the vessel. In calculating the cost of this rulemaking on the ocean transportation industry, many of the assumptions, including how vessel types were categorized, arose from this basic understanding of how cargo and ballast water are moved in different sectors of the industry.

Population Affected

As described in the previous chapter, this rule will affect all vessels that enter the waters of the United States after operating beyond the EEZ that carry ballast water in dedicated ballast water tanks (except those vessels that are expressly exempted in this proposed rule). Vessels entering the Great Lakes Region and Hudson River were not included in this analysis as they are covered under mandatory provisions of 33 CFR 151 subpart C.

Vessels that are not included within the population are either small vessels that operate exclusively within the U.S. EEZ or vessels that do not carry a sufficient amount of ballast water to be considered within this analysis. Vessel types for which adequate arrival or ballast operations information was unavailable were also excluded from the analysis. These vessels are listed in Table 1.

Table 1.
Vessels Excluded from the Cost Analysis

Dredgers	Pusher tugs
Log-tipping ships	Fishing vessels
Cable-layers	Crane ships
Yachts	Drilling ships
Landing craft	Sailing vessels
Trawlers	Training ships
Utility vessels	Offshore tugs
Production testing vessels	Well stimulation vessels
Research vessels	Offshore supply vessels

Vessel Types

Vessels were grouped by service and size. Each vessel was identified in *Lloyd's Register* through the seven-digit IMO number reported to each database. The ship type reported by *Lloyd's Register* for each vessel was recorded [44]. For the purposes of this analysis, vessels in similar service were grouped together according to Table 2.

Bulk cargo vessels and tank vessels were then further divided into subcategories by DWT according to commonly used industry size ranges [33]. The largest of these vessels were also placed into subgroups according to their ability to navigate the Panama and Suez Canals. Container vessels were grouped into six subgroups based both on TEU capacity and ability to transit the Panama Canal. Panama Canal operations are such that vessels longer than 294 meters or wider than 32 meters are unable to pass through the locks.

Table 2.

Vessel Type Definitions

Vessel Type (this analysis)	Ship Type (Lloyd's Register)
BULK1 through BULK3	Ore/Bulk/Oil Carriers Bulk Carriers Cement Carriers Great Laker Heavy Load Carrier Barge Carrier Limestone Carrier Ore Carrier Ore/Oil Carrier Sand Carrier Wood Chip Carrier
TANK1 through TANK5	Fruit Juice Tanker Oil Tanker Products Tanker Shuttle Tanker Tanker Tank Barge Vegetable Oil/Wine/Beer Tanker
CHEM	Chemical Tanker
GAS	Liquefied Gas Carrier Liquid Petroleum Gas (LPG) Tanker Liquid Natural Gas (LNG) Tanker
FEEDER FEEDERMAX HANDY SUBPANAMAX PANAMAX POSTPANAMAX	Container Ship
PASS	Passenger Ferry Passenger Ship
GENCARG	General Cargo Deck Cargo Ship Refrigerated Cargo Pallets Carrier Other Specialized Cargo
RORO	Ro/Ro Cargo Ferry[a] Ro/Ro Cargo with Lo/Lo Access[b] Ro/Ro Cargo/Vehicle Carrier Passenger Ro/Ro Car Ferry
COMB	Bulk Carrier + Vehicle Decks Passenger/General Cargo General Cargo with Ro/Ro Facility Container Ship with Ro/Ro Facility

[a] Ro/Ro is a vessel with roll-on, roll-off access.
[b] Lo/Lo is a vessel with lift-on, lift-off access.

Next, vessels were grouped by size and service into one of twenty vessel types, based on data from *Lloyd's Register*, as shown in Table 3. Vessels were categorized according to these classifications to more accurately estimate costs based on pump capacities, which would vary by vessel type and size.

Table 3.
Number and Type of Vessels Affected by the Proposed Rule

Type of Vessel	Classification Criteria [33]	Number of Vessels 1999	Number of Vessels 2000	Average[a]
BULK1	< 50,000 DWT	1,756	1,779	1,770
BULK2	50,000–80,000 DWT	670	701	690
BULK3	> 80,000 DWT	185	141	170
TANK1	< 35,000 DWT	110	128	120
TANK2	35,000–120,000 DWT	509	555	540
TANK3	120,000–160,000 DWT	123	124	130
TANK4	160,000–320,000 DWT	100	117	110
TANK5	> 320,000 DWT	29	20	25
CHEM	All sizes	496	517	510
GAS	All sizes	160	180	170
FEEDER	< 500 TEU	17	11	20
FEEDERMAX	500–1000 TEU	72	58	70
HANDY	1000–2000 TEU	272	279	280
SUBPANAMAX	2000–3000 TEU	210	220	220
PANAMAX	> 3000 TEU[b]	295	270	290
POSTPANAMAX	> 3000 TEU[c]	78	83	90
PASS	All sizes	272	279	280
GENCARG	All sizes	1,485	1,418	1,460
RORO	All sizes	428	443	440
COMB	All sizes	18	24	30
Total		**7,285**	**7,347**	**7,420**

[a] Mathematical average of 1999 and 2000 data, rounded up to the nearest 10.
[b] Vessel length and beam within Panama Canal limits.
[c] Vessel length and beam exceed Panama Canal limits.

As shown, the majority of the vessels in the population (35 percent) are bulk freighters. Next highest percentages are general cargo vessels (20 percent), container vessels (13 percent), tank vessels (12 percent), and vehicle carriers (6 percent). The remaining are chemical carriers, gas carriers, passenger vessels, and combination vessels (totaling 14 percent).

The population of vessels was assumed to be constant over the period of the analysis. Though it is generally agreed that the world fleet is expanding in capacity, the growth of the world fleet has been on the order of 2 percent for the last 5 years [65]. The uncertainty inherent in our cost model and the effects of our simplifying assumptions are most likely greater than 2 percent, thus we did not factor fleet growth into our cost analysis.

Vessel Arrivals

All commercial vessel visits for the years 1999 and 2000 were collected from MSMS. These data are gleaned from the Coast Guard's Marine Safety Information System (MSIS), which was the database for commercial vessel and marine safety activities until December 2001. Vessel arrival data for 1999 and 2000 did not indicate if the vessel was transiting from a foreign port or arriving from another U.S. port. We made assumptions about inbound traffic coming from outside the U.S. EEZ based on the number of days between U.S. port calls. If the time between sequential calls to any U.S. port exceeded 8 days, the assumption was made that the vessel had transited outside the EEZ. The total number of visits from outside the U.S. EEZ for the year, for each vessel, was then calculated. Data from arrival notices submitted to the Coast Guard's NVMC in 2002 were used to develop a picture of transit patterns for ships making port calls to the U.S (last port of call information is not available prior to 2002 from Coast Guard data).

The last port of call, listed in the NVMC data set, was assigned to a port zone to group the ports geographically. U.S. ports were similarly grouped into coastal zones (East Coast, Gulf Coast, West Coast, etc.). Thirteen transit tracks were then identified that accounted for most of the sea areas vessels would transit. Transit track descriptions are found in Table 4.

Table 4.
Transit Track Definitions

Track	Description
1	Northern Europe to the East Coast
2	Mediterranean to the East Coast
3	Northern Europe to the Caribbean and Gulf of Mexico
4	Mediterranean to the Caribbean and Gulf of Mexico
5	East Asia to the West Coast
6	Southeast Asia to the West Coast
7	South America to the East Coast
8	West Africa to the East Coast
9	Central America to the Pacific Islands
10	East Asia to Alaska
11	West Africa to the West Coast and Hawaii
12	All EEZ
13	Southeast and East Asia to the Pacific Islands

Vessel routes in which the vessel would typically not travel more than 200 miles from any land were grouped into one transit track, track 12—All EEZ, and the probability of exchange within that track was zero. It is understood that all possible transits are not captured by the 13 transit tracks listed. These transit tracks were assumed, however, to be the most likely routes for shipping. Where two tracks could have been assigned, the transit track with the lower probability of wave heights acceptable for exchange was selected. For example, if a vessel departs from Calcutta, India, bound for New York, it is equally likely that it would transit east through the Indian and Pacific Oceans versus west through the Mediterranean Sea and Atlantic Ocean. In this case, we assigned this arrival to track 2 (Mediterranean to the East Coast) because this transit track is less likely to have sea states conducive to ballast exchange than either of the tracks through Asia (5 or 6).

The transit track information allowed the probability of weather conducive to conduct an exchange to be applied to the cost calculation. One of the primary concerns for vessels conducting mid-ocean ballast water exchange, is the effect of interim steps in the process on the vessel's list, trim, and stability during an open-ocean transit. For example, pumping ballast from tanks close to the bow could raise the bow out of the water and cause the bow of the vessel to "slam" in waves, increasing the risk of structural damage to the vessel. Removing water from the stern could lighten the vessel so as to expose portions of the rudder and propeller, affecting steering and propulsion. Information from *Lloyd's Register* for bulk cargo vessels and information from the American Bureau of Shipping for container vessels was used to estimate the wave-height limits for conducting mid-ocean ballast water exchange [1, 43].

It was determined that the maximum wave height to conduct a ballast water exchange would be 3 meters for bulkers, tankers, gas carriers, and ROROs based on the assumption that they had relatively little subdivision—cargo areas resulted in the vessel divided into fewer, larger compartments. All other vessels had greater subdivision and were assumed to be able to conduct ballast water operations in wave heights up to 6 meters. Wave height statistics were used to determine the probability that weather conditions would permit ballast water exchange in the sea areas applicable to each vessel track (see Appendix B) [31]. Wave height statistics were not applicable in the All EEZ track, since exchanges are not to be conducted in these waters.

The distribution of vessel types across all 13 transit tracks was determined from the 2002 NVMC data. Operating under the assumption that similar vessel types carried cargo to and from the same regions of the U.S. in 1999, 2000, and 2002, the distribution of vessel types across transit tracks from 2002 was applied to the vessels in the 1999 and 2000 arrival data from MSMS.

Determining the amount of ballast water typical for each vessel type presented several challenges. The *Lloyd's Register* data do not reveal ballast water capacity for each vessel type, although clean and segregated ballast capacities are typically available for petroleum tank vessels, and ballast tank capacity is available to a limited extent for other vessel types. The ballast water and invasive species literature includes several shipping studies that catalogue ballast water capacity for various individual vessels. In looking at both of these sources, we believed the number of vessels in each vessel type was insufficient to determine ballast capacity with a high degree of confidence. Ballast water management data for arriving vessels have been collected through NBIC. These data were reviewed and reported ballast water capacities were averaged for vessel types. With few exceptions, there was good agreement between the *Lloyd's Register* information and the NBIC reports, and there was also some limited agreement between the representations of ballast water capacity for vessels in the NIS literature and the NBIC reports (see Appendix A). As a result, it was decided to use the average of reported ballast water capacities revealed in the NBIC data for each vessel type.

In determining the amount of ballast water involved in the exchange, three volumes of ballast tank capacity are pumped for vessels completing a flow-through exchange, while two volumes of the ballast tank capacity are pumped for sequential exchange. Bulkers, tankers, and gas carriers were assumed to complete flow-through exchanges and all other vessel types complete sequential exchange.

In determining pumping costs, a uniform cost for pumping one cubic meter of ballast water was calculated. The cost calculated was based on pump capacities ranging from 220 m^3/hr to 2,280 m^3/hr. Kilowatt ratings of each motor were used with a motor-to-pump efficiency assumed to be 60 percent, fuel consumption for a ship's service generator of 0.576 lb/kw, and a fuel cost of \$0.125/lb to obtain the cost of operating the pump for 1 hour [59]. This was then applied to the capacity of each pump to determine the cost for pumping a cubic meter of ballast water. These costs ranged from \$0.012/m^3 for the mid-sized pumps to \$0.015/m^3 for the smallest and largest pumps. We used a conservative estimate of \$0.013/m^3 exchanged, since most vessels transiting

U.S. waters are in the mid-sized range. Table 5 lists ballast pumps by capacity, rating, and capital cost.

Table 5.
Ballast Pump Information

Capacity (m^3/hr, approx.)	Rating (kw)	Capital Cost
220	37	$15,000
450	56	20,000
680	75	25,000
910	93	30,000
1,140	112	35,000
1,360	150	40,000
1,590	168	45,000
1,820	186	50,000
2,050	224	55,000
2,280	261	60,000

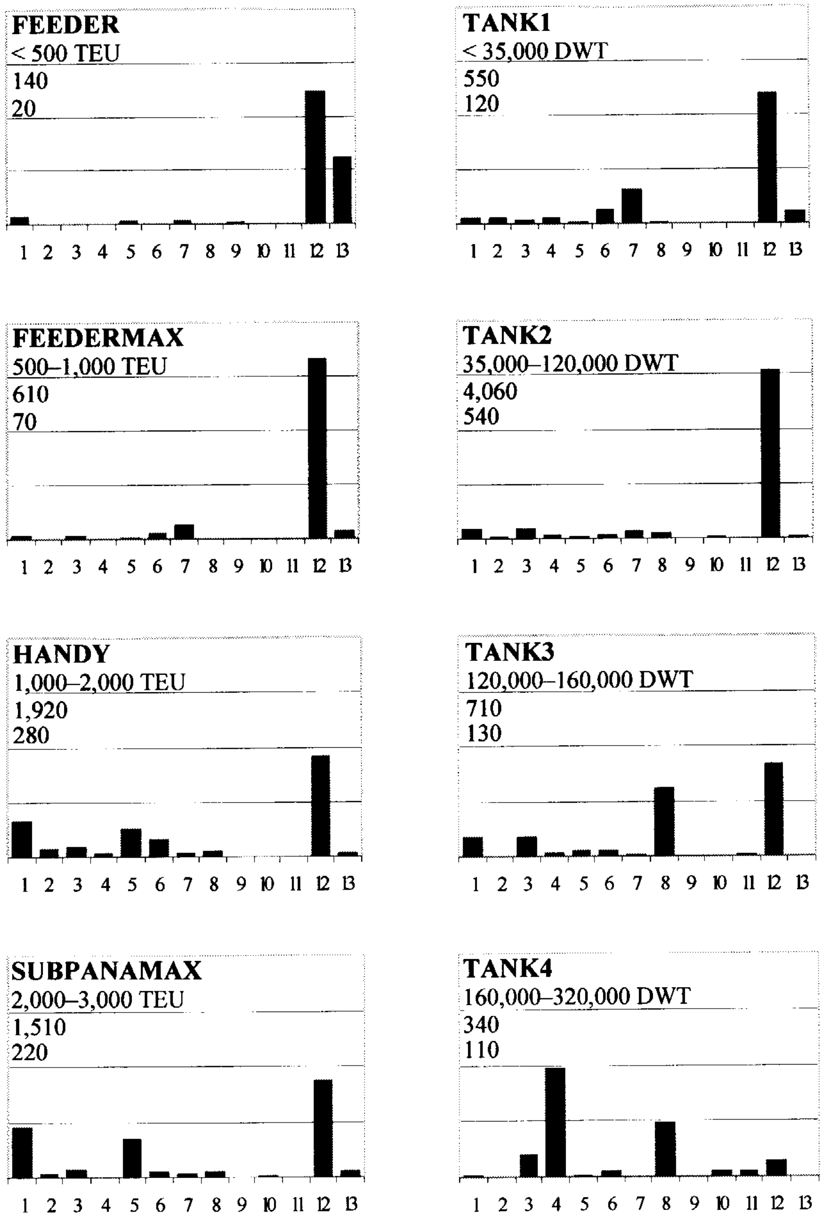
Another important component in the cost of ballast water exchange was the additional maintenance cost accrued because the ballast pumps are required to pump the ship's capacity in ballast water for every trip into the U.S. EEZ when cargo operations are planned. It was clear from the vessel arrival data that there are many vessels that make only one or two annual port calls in U.S. waters while other vessels may make multiple voyages into U.S. ports each month. It was not possible, however, to project what proportion of ballast pump run-time would be added to individual vessels as a result of this rule. Through personal communications with various members of the ocean transportation industry, average annual maintenance costs were estimated to be on the order of 10 percent of the ballast water system's capital cost. In order to adequately account for the extra maintenance burden, a uniform annual maintenance cost of 10 percent of the capital cost of one ballast pump was added for each vessel conducting exchanges, whether a vessel made a single U.S. port call per year or 20 visits to U.S. waters. This maintenance cost was assumed to cover replacement parts for pumps and to include impellers and maintenance of piping system components such as valves.

Cost Analysis

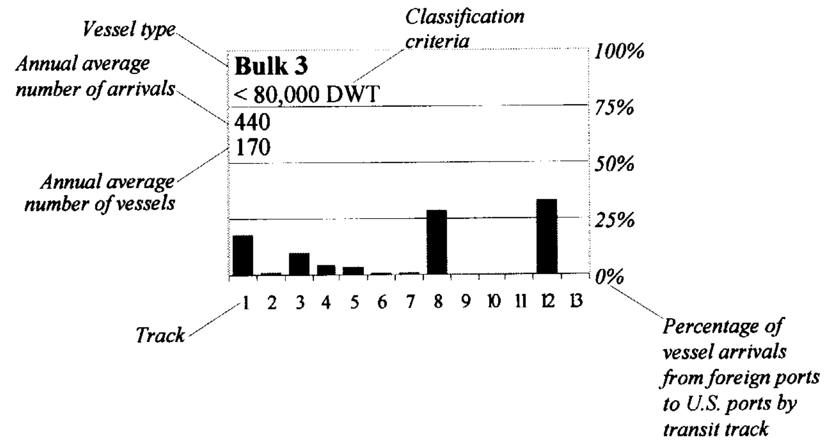
Traffic Flows

One of the results of our analysis was a better understanding of traffic patterns for vessels arriving from foreign ports. Figure 1 (next two pages) shows the distribution of arrivals across transit tracks for each vessel type. For example, FEEDER vessels are small container vessels with a cargo capacity less than 500 TEU. In looking at averages for 2 years of arrival data, 1999 and 2000, we see that most of the approximately 140 arrivals by approximately 20 vessels were from foreign ports with transits that lie within 200 miles of land (track 12). The track with the next highest percentage of arrivals is track 13, where these small container vessels are transiting from Southeast and East Asia to U.S. ports in the Pacific Islands.

Figure 1
Vessel Arrivals from Foreign Ports to U.S. Ports by Transit Track

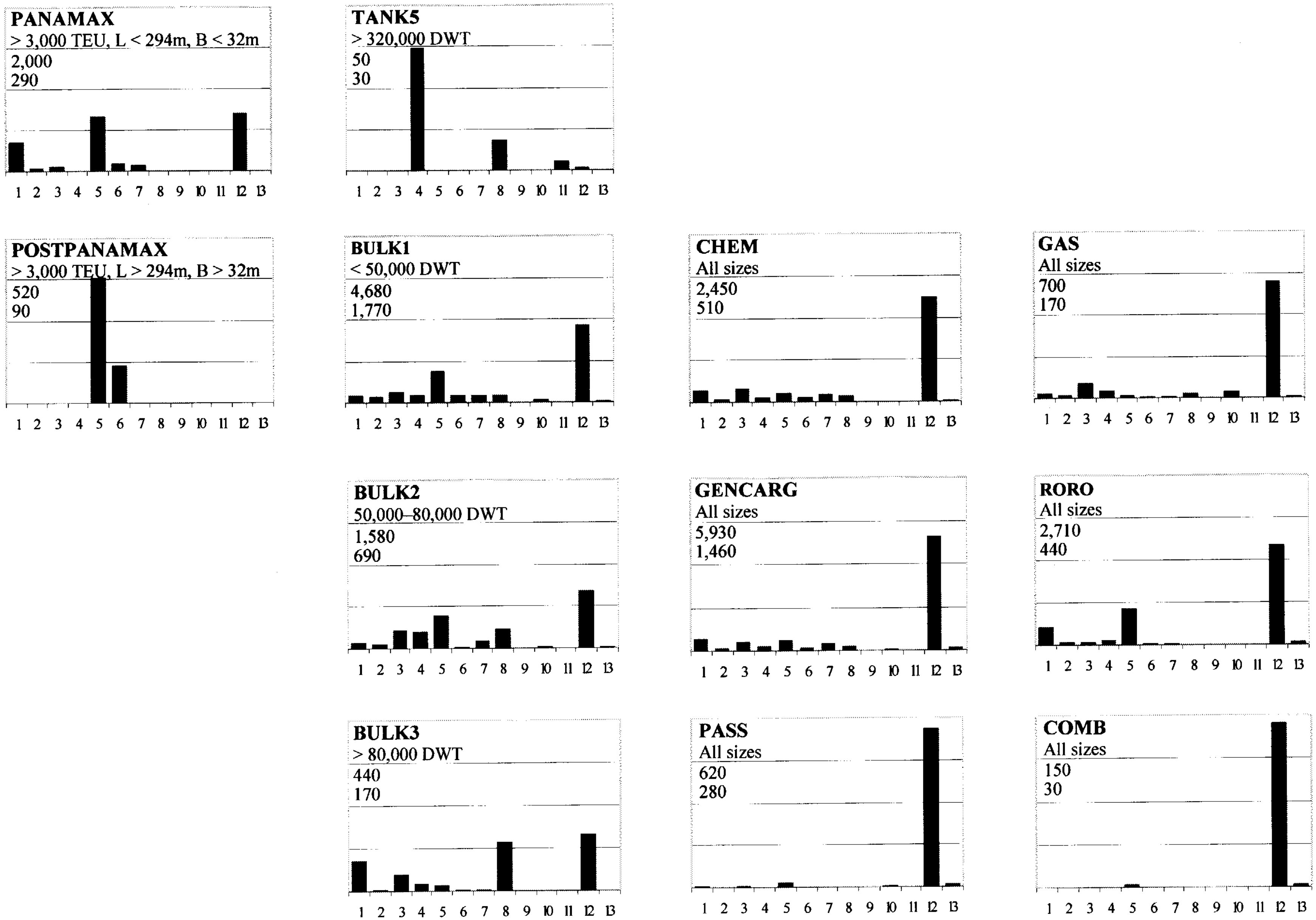


Example key



Transit track descriptions

1 Northern Europe to the East Coast
2 Mediterranean to the East Coast
3 Northern Europe to the Caribbean and Gulf of Mexico
4 Mediterranean to the Caribbean and Gulf of Mexico
5 East Asia to the West Coast
6 Southeast Asia to the West Coast
7 South America to the East Coast
8 West Africa to the East Coast
9 Central America to the Pacific Islands
10 East Asia to Alaska
11 West Africa to the West Coast and Hawaii
12 All Exclusive Economic Zone
13 Southeast and East Asia to the Pacific Islands


PANAMAX
> 3,000 TEU, L < 294m, B < 32m
2,000
290
TANK5
> 320,000 DWT
50
30
POSTPANAMAX
> 3,000 TEU, L > 294m, B > 32m
520
90
BULK1
< 50,000 DWT
4,680
1,770
CHEM
All sizes
2,450
510
GAS
All sizes
700
170
BULK2
50,000–80,000 DWT
1,580
690
GENCARG
All sizes
5,930
1,460
RORO
All sizes
2,710
440
BULK3
> 80,000 DWT
440
170
PASS
All sizes
620
280
COMB
All sizes
150
30
1 2 3 4 5 6 7 8 9 10 11 12 13

As shown, all of the small- and medium-sized container vessels (up to 3,000 TEU) primarily transit within 200 miles of land, though fewer transits in this track are shown as vessel size increases. In contrast, the largest container vessels, those designated POSTPANAMAX, carrying over 3,000 TEU and having dimensions that preclude transit through the Panama Canal, have arrivals concentrated in transit tracks 5 and 6—East Asia to the West Coast and Southeast Asia to the West Coast. Thus, these largest container vessels are exclusively engaged in cargo carriage in the Pacific Rim, bringing finished goods to and from the United States.

Tank vessels and bulk carriers move cargo in shipload lots and carry ballast water in the absence of cargo, rather than in addition to cargo to optimize vessel stability and performance. When looking at the relationship between the size of the vessel and the transit tracks frequented, however, the tank vessel and bulk carrier graphs show a similar distribution trend as those for container vessels. Tank vessels, dominated by petroleum tankers, were divided into five categories. The smallest vessels, those less than 120,000 DWT described by TANK1 and TANK2, have arrivals predominantly from the EEZ (track 12). These are most often petroleum product tankers, though smaller tankers also carry wine, molasses, edible oils, concentrates, and other liquids. The concentration of arrivals from in the transit track that remains within 200 miles of shore shows the influence of tanker traffic from South America and the Caribbean arriving at Gulf Coast ports and never transiting beyond 200 miles from land. Petroleum from Venezuela is seen in the concentration of TANK1 arrivals in transit track 7, South America to the East Coast.

As size increases within petroleum tankers up to 160,000 DWT and as cargo changes from product to crude oil, the distribution of arrivals across transit tracks changes. We see a shift from transits within 200 miles of shore to transits from the Middle East through the Mediterranean as shown in TANK4, where almost 50 percent of the arrivals are in transit track 4. The Ultra Large Crude Carriers (ULCCs) are captured in TANK5, and nearly 75 percent of these arrivals are from the Mideast through the Mediterranean.

Bulk carriers show a similar, though less pronounced, trend than container and tank vessels. Nearly 50 percent of the arrivals for the smallest bulk carrier, BULK1, are within transit track 12, transits within 200 miles of shore. For the largest carriers, BULK3, the number of arrivals from foreign ports inside 200 miles has dropped to just over 30 percent followed closely by those arrivals to the East Coast from West Africa (track 8). The middle group of bulk carriers, those between 50,000 and 80,000 DWT, is still dominated by transits within 200 miles, but there are significant arrivals in transit tracks 3, 4, 5, and 8, which show the influence of both mineral and grain shipments in the bulk trades.

The remaining vessels were not divided by size, primarily due to the small number of vessels in each category. In the case of general cargo vessels, GENCARG, there were almost 1,500 vessels that arrived in U.S. waters; however, their wide variance in size, cargo, route, and service made further subdivision impractical. The arrival distributions for these remaining six vessel types are remarkably similar, showing that most of these vessels arrive from foreign ports with transits 200 miles from land. In the case of passenger vessels and combination carriers, PASS and COMB, transit track 12 accounts for nearly all the U.S. arrivals. ROROs show over 50 percent of arrivals in track 12, but also have significant arrivals in track 5 and track 1, primarily vehicle deliveries from Asia and Europe.

The dominance of vessel arrivals in track 12, where transits are within 200 miles of land for most vessel types, highlights the difficulty in relying on ballast water exchange to have a significant effect on reducing the number of NIS introductions. None of the vessels transiting track 12 have the opportunity to conduct a mid-ocean ballast water exchange since they never travel over 200 nautical miles from land. As a result, the ballast water discharged from these vessels into U.S. waters may contain NIS that could successfully be introduced and could subsequently become invasive. If these same vessels were to conduct an exchange in coastal areas, the risk of invasive species introduction remains. While it is possible to analyze these arrival data and assign costs for compliance with a rule mandating ballast water management, the rule does not eliminate the transport of NIS into U.S. waters through the vector of ballast water from ships.

Cost Calculations for Ballast Water Exchange

Using large bulk carriers as an example, this section discusses the specifics of the cost calculation. The cost for all the bulk carriers greater than 80,000 DWT (BULK3), transiting from Northern Europe to the East Coast (track 1), based on calendar year 2000 arrival data would be as follows.

Of the 419 foreign arrivals in 2000 for the category BULK3, 18 percent or 76 arrivals were from Northern Europe to the East Coast. These vessels were subject to sea states where wave heights were 3 meters or less about 57 percent of the time and thus would be considered able to do an exchange 57 percent of the time. Bulk carriers of this size range were found to have an average ballast capacity of 63,000 m^3, and this capacity would be pumped by the vessel's ballast system three times to accomplish a flow-through exchange. With the $0.013/$m^3$ cost of moving ballast water, these BULK3 vessels on this track would have a total annual cost of $106,957—

> 76 arrivals × 57% probability of favorable sea state × 63,000 m^3 ballast/arrival × 3 volumes of total ballast capacity pumped × $0.013/$m^3$ ballast pumped ≈ $106,957

Added to the costs for all other transit tracks, the total cost of exchanges for BULK3 is $480,691.

The cost of maintenance for the ballast pumps was then calculated. We determined how many of the BULK3 vessels in this category transited within 200 miles of shore exclusively (track 12). We subtracted these vessels from our population, since we determined they would seldom, if ever, conduct an exchange for compliance with this rulemaking. For the remaining vessels that transit at least once outside the EEZ (123 vessels), we assigned a maintenance cost for these vessels. We assumed that maintenance would be 10 percent of the capital cost of the pumping system or $3,500 annually. For the entire BULK3 category, the annual maintenance cost was determined to be $429,980. When added to the $480,691 cost of conducting exchanges, this yielded a total cost of exchange operations for BULK3 cargo vessels of roughly $911,000 annually. These same calculations were conducted using 1999 data, and the 1999 and 2000 results were averaged.

For more detailed information on the ballast water exchange cost calculations for BULK3 vessels and all vessels in our analysis, refer to Appendix C.

Summary of Estimated Costs for Ballast Water Exchange

Table 6 presents the estimated total cost of exchange for each of the twenty vessel types along with summary information for the analysis. As shown, the probability a vessel performs exchange (third column) is unique for each vessel type. Recalling Figure 1 and the bar graph for vessel type BULK1, approximately 45 percent of the vessel arrivals were in track 12 (all EEZ, 200 miles from shore) with no possibility of exchange. The remaining 55 percent of the vessels then transited through sea areas where wave heights further reduce the possibility of exchange to 36 percent overall for BULK1 vessels. Again as container vessels, bulk carriers, and tank vessels increase in cargo capacity and have fewer transits within 200 miles of shore, there is an increase in the probability these vessels will be able to conduct an exchange because of the tracks these vessels most often transit. The probability for exchange for tankers, for example, increases from a weighted probability of 16 percent for TANK2 to 72 percent for TANK5. The predominant ocean crossings and ability to handle more severe weather conditions is reflected in the high overall probability for an exchange in the largest container vessels, POSTPANAMAX, with a weighted probability of 96 percent.

We estimate the total annual cost of the rulemaking will be approximately $16 million. It is important to remember that the assumptions we made regarding exchange likely overestimate annual cost. For example, we assume that all ballast will be exchanged on every voyage to a U.S. port from outside the U.S. EEZ. Most operators will likely exchange only the tanks they need to before entering port depending on the cargo operations they intend to perform once in the United States. Also, we assigned a uniform annual maintenance cost to every vessel that made at least one transit outside the U.S. EEZ; for many vessels that only make one port call in the United States from outside the EEZ, this would overstate the annual cost to this vessel. We believe, however, that even though we could be overestimating the annual cost of the proposed rulemaking, our costs certainly represent the magnitude of expenditures we would expect to see.

Table 6.
Estimated Annual Cost of the Proposed Rule

Vessel type	Average vessels[a]	Prob. vessel performs exchange[b]	Average annual exchanges[c]	Cost per exchange[d]	Annual maint. cost per vessel conducting exchange[e]	Total annual exchange cost ($Millions)[f]	Total annual maintenance cost ($Millions)[f]	Total annual cost ($Millions)[f]
BULK1	1,770	36%	1,680	$690	$2,500	$1.159	$3.482	$4.641
BULK2	690	45%	710	1,388	3,000	0.981	1.767	2.748
BULK3	170	47%	210	2,457	3,500	0.500	0.497	0.997
TANK1	120	30%	170	250	2,500	0.042	0.219	0.261
TANK2	540	16%	670	1,229	3,000	0.815	1.278	2.093
TANK3	130	42%	300	2,110	3,500	0.629	0.389	1.018
TANK4	110	68%	230	3,479	5,500	0.789	0.569	1.358
TANK5	30	72%	40	3,627	6,000	0.118	0.140	0.258
CHEM	510	37%	900	278	3,000	0.249	1.192	1.441
GAS	170	20%	150	452	3,000	0.064	0.379	0.443
FEEDER	20	38%	60	75	1,500	0.004	0.015	0.019
FEEDERMAX	70	17%	110	96	1,500	0.010	0.032	0.042
HANDY	280	52%	1,000	208	1,500	0.207	0.313	0.520
SUBPANAMAX	220	54%	810	361	2,000	0.290	0.306	0.596
PANAMAX	290	62%	1,250	447	2,000	0.555	0.527	1.082
POSTPANAMAX	90	96%	500	497	2,000	0.247	0.161	0.408
PASS	280	6%	40	68	1,500	0.003	0.069	0.072
GENCARG	1,460	33%	1,930	117	2,000	0.226	1.924	2.150
RORO	440	26%	700	200	2,500	0.140	0.831	0.971
COMB	30	4%	10	190	2,000	0.001	0.021	0.022
Total	**7,420**		**11,470**			**$7.029**	**$8.799**	**$15.828**

a From 1999 and 2000 MSMS data. Mathematical average rounded up to the nearest 10.
b Weighted average across transit tracks. This probability was not used in the analysis, but gives the reader a sense of the percentage of vessels conducting exchange by vessel type.
c From 1999 and 2000 MSMS data. Mathematical average rounded up to the nearest 10.
d Total ballast capacity (m^3) × total volumes exchanged × cost per m^3 exchanged.
e Ballast pump capital cost × 10 percent.
f Average of results from 1999 and 2000 data.

Cost Calculations for Ballast Water Management Plans

The proposed rule mandates that a ballast water management plan be kept onboard each vessel. This plan will be written during the first year the rule is in effect (2004). We estimate that the plan will require 8 hours to compile and complete, and each hour will cost $100 in labor costs. This is a loaded labor rate that includes wages and fringe benefits. For the approximately 7,420 vessels affected by the proposed rule, the ballast water management plan will cost $5,936,000—

7,420 vessels × 8 hours × $100/hour = $5,936,000

Summary of Total National Cost

Table 7 presents the present value (PV) cost of the proposed rule over the 10-year period of the analysis (where the first year, 2003, has no cost). The rule is anticipated to enter into effect in early 2004. As shown, the total 10-year PV cost of the rule is approximately $117 million. The cost in 2004 is higher than in subsequent years because the cost of developing ballast water management plans is incurred during this year.

Table 7.
PV Cost of the Proposed Rule (2003–2013, 7 percent discount rate, 2003 dollars)

Year	Total Cost ($M)	PV Cost ($M)
2003	$ -	$ -
2004	21.764	20.340
2005	15.828	13.825
2006	15.828	12.920
2007	15.828	12.075
2008	15.828	11.285
2009	15.828	10.547
2010	15.828	9.857
2011	15.828	9.212
2012	15.828	8.609
2013	15.828	8.046
Total	**$164.216**	**$116.717**

3. Benefits

Introduction

The complexity of species transport, introduction, and survival makes prediction of where and when bioinvasions may occur extremely difficult [13, 14, 16, 50]. Simply because an environment is inoculated with a new species does not necessarily mean that the species will become established. A complex series of biological and environmental factors influence the establishment of NIS from ballast water discharge [14]. First an organism must be taken up and survive the rigors of the ballasting process. The organism must then survive the transport to a new area. The longer the voyage, the lower the potential for survival [14]. The organism must then survive introduction into the new environment. When organisms are discharged with ballast water they encounter new physical conditions without time to acclimate. Survival in the new environment can depend on short-term tolerances to the new physical environment as well as the overall compatibility of the environmental conditions of the receiving and donor waters [32]. Initial survival of an individual does not constitute establishment—establishment is achieved only if a species successfully survives and reproduces over several generations within the new ecosystem [71]. As a result, survival rates of introduced NIS are typically low for any given port arrival [45]. However, with large volumes of ballast water containing high concentrations of NIS and the accumulation of inoculations over time, even a low rate of survival can pose a bioinvasion threat.

While ballast water has been cited as a major vector of aquatic NIS to U.S. waters, several other vectors also exist. NIS imported for aquaculture may escape farm containments and become established. Fish and other organisms are frequently imported for private and public aquaria and have the potential to escape or to be released from confinement. The discarding of live seafood product, aquarium plants and animals, or other aquatic species contributes to NIS introductions. Recreational and commercial fishing industries may introduce NIS either accidentally (seafood imports) or intentionally (fish stocking). Research and teaching organizations often import NIS for testing and research, and improper handling can result in introductions. In addition, vectors other than ballast water may be associated with the shipping industry. Aquatic organisms can attach to boat hulls, trailers, anchors, and other compartments of commercial and recreational vessels. While all of these vectors can lead to NIS introductions, the proposed rule addresses ballast water discharge only.

Thus, the benefits realized as a result of the rule are expressed as a result of a vessel's ability to conduct mid-ocean exchange. The cost of the rule was calculated for all vessel arrivals coming into U.S. waters from outside the U.S. EEZ. The increase in vessels conducting ballast water exchange as a result of the rule will likely reduce the probability of inoculations from ballast water discharge. This, in turn, reduces the probability that a species will proliferate and subsequently become invasive. The benefits of the rule are the damages that might be avoided as a result of averted invasions.

While this analysis attempts to quantify the annual benefit if NIS inoculations are avoided, our estimates carry high levels of uncertainty. Our cost analysis contained many simplifying assumptions to make calculations tractable while obtaining realistic results. These simplifications were carried forward to the benefits analysis, where further assumptions were made. Further research, more complete data, and greater understanding of invasion biology will help refine our analysis in the future. The estimates presented in this analysis are simplified, but we consider them to be reasonable given the current state of the science and what we know about the effectiveness of ballast water exchange.

Taking Regulatory Action in the Face of Uncertainty

The Coast Guard is taking regulatory action despite the high level of uncertainty inherent in invasive species biology. Congress required the Coast Guard to take regulatory action, first through a voluntary BWM program, then a mandatory BWM program in NISA. BWM is admittedly an incomplete measure to address aquatic invasions. Given what we currently know about NIS and advanced treatments to control their introduction, however, mandatory BWM is a reasonable first step in controlling the problem. BWM will not prevent all—in fact, most—invasions; but the invasions it could prevent are likely to carry significant benefits in terms of avoided damages. Because of the current inability to predict the course and trends of invasion biology, prevention or reduction of invasions is the most effective first line of defense against the impacts of NIS [28, 30, 45].

BWM is available to virtually all ships—with adjustments to operating procedures, but without costly retrofits or expensive technology installations. The Coast Guard's mandatory BWM requirements are cost effective; costs associated with BWM involve fuel and increased usage of the ballast system—but the BWM program does not require vessels to divert from their planned transit or excessively delay their voyages. Given the state of the science both in terms of invasion biology and advanced technology, the tradeoff of lesser protection for lesser cost is justified through BWM.

Salinity, temperature, and turbidity are key factors in how ecosystems are defined and how they function. The salinity of ballast water frequently does not match the salinity of the system waters into which it is discharged. This fact is a fundamental principle underlying the utility of ballast water exchange in removing potentially invasive organisms. Many of the organisms in ballast water taken on in coastal waters do not survive the mid-ocean exchange, even though they may remain entrained within the ballast tank. They do not survive because of their incompatibility with the new ballast tank environment due to differences in salinity and temperature. For the same reason, mid-ocean organisms taken into the ballast tank during exchange that may survive the transit to the receiving waters, will likely not survive the injection into the new ecosystem, again due to differences in temperature and salinity.

There is also little reason to be concerned with the higher salinity mid-ocean water of the exchanged ballast tank being pumped into fresh or estuarine port or harbor waters. The impact of mid-ocean water injected into port ecosystems is minimal. Although exceptionally large volumes of ballast water can be discharged, these single-pulse volumes are typically minor when compared to the overall volume and flushing characteristics of most ports. It is unlikely that ballast water discharges will significantly affect the salinity, temperature, or turbidity of receiving waters.

Thus, although there is much debate concerning the effectiveness of ballast water exchange in removing invasive species from all ballast water discharged into U.S. ports, it remains a potent first step in a management program designed to prevent and control the spread of invasive species into U.S. waters as directed by NISA.

Damages of NIS

NIS introductions to U.S. waters are occurring at increasingly rapid rates [14, 61]. Invasions of NIS can fundamentally alter the ecology of an area, with potential impacts on biodiversity and economic systems, and possibly human health [64, 71]. NIS introductions have been cited as the second greatest threat to biodiversity behind habitat loss [69]. Aquatic NIS are considered one of the most important issues facing the maritime community [63]. As stated throughout this analysis, ballast water discharge is recognized as a major vector for the introduction of aquatic NIS [5, 10, 15, 60, 61].

The Special Case of the Zebra Mussel

Zebra mussels have become the most notorious aquatic invader in the United States. It was, in fact, the devastating invasion of zebra mussels that prompted legislative and regulatory action in the 1990s. Damages from the spread of zebra mussels throughout the eastern United States are extensive and well documented. While we do not expect to prevent the "next" zebra mussel through the proposed rule, the impacts wrought by this species warrant special attention.

Before zebra mussels made their appearance in the mid-1980s, the Great Lakes were somewhat murky, preventing sunlight from shining into some depths of water, preventing the growth of many aquatic plants. Some fisheries were making a comeback following cleanup activities that began to reduce the pollutants from municipalities and industries. Then, in about 1985, freight vessels traveling from European waters took on ballast water containing zebra mussels that had been common throughout Europe for more than a century. The mussels found an ideal environment and their population exploded. The zebra mussel, a mollusk less than an inch long, has now spread into most of the aquatic ecosystems in the eastern United States and is expected to invade most freshwater habitats throughout the nation within approximately 20 years [7]. Their reproductive success is due in large part to the organism's ability to lay one million eggs a year [48]. The native clams, finding less food in the clearer water began to die off. The changing environment took its toll on native fish populations as well. As zebra mussels are able to adhere to almost any solid surface, they began accumulating and causing buoys to sink and clogging water intakes at power and water plants. Mussel densities reached 700,000 per m^2 in some locations [27].

The monetary damages are severe and widespread—

- 339 facilities in the Great Lakes region, including recreational facilities, public agencies, industries, and utilities, reported total zebra mussel-related expenses of over $69 million (a mean expenditure of $206,000 per facility) from 1989 through 1995 [52]. Total annual expenditures at these facilities increased from $234,000 in 1989 to over $17 million in 1995 [52].

- Great Lakes municipalities spend $20,000 to $360,000 per year on zebra mussel control at drinking water intakes [4, 26].

- At least 12 nuclear power plants average $825,000 in annual zebra mussel control costs [26].

- From 1989 to 1994, documented cumulative costs associated with the zebra mussel for water users were $120 million [34].

- Zebra mussel impacts were estimated to be $750 million to $1 billion for the period 1989 to 2000 [10].

Impacts to Water-Dependent Infrastructure

Invasive invertebrates introduced via ballast water discharge, such as the zebra mussel, have affected water-dependent infrastructure by biofouling intake pipes and screens, causing equipment malfunction and overheating, and jamming valves and other mechanisms. These impacts have affected electric power generation stations, drinking water treatment plants, industrial facilities, and navigation lock and dam structures. The organisms in these studies have all been associated with ballast water.

- One study conducted the early 1980s estimated that fouling damage from the Asian clam was approximately $1 billion per year [64].

- In the summer of 1998, local authorities in the Sacramento River delta dealt with 30,000 adult Chinese mitten crabs migrating downstream, which clogged the fish filtering and trash screens at the Tracy irrigation pumps daily [10, 19].

- The green mussel is established in Tampa Bay and is currently causing biofouling problems at power plant cooling water intakes [29].

Impacts to Commercial Fishing, Recreational Fishing, and Water-Dependent Tourism

Invasions of NIS can disrupt commercial fisheries (both capture and culture) and recreational fisheries, subsequently adversely affecting local and regional economies. Similarly, water-dependent tourism and recreational activities associated with fishing, boating, swimming, and scuba diving can be degraded by NIS.

- Invasive fish species such as the sea lamprey, European ruffe, and round goby threaten native sport-fish populations in the Great Lakes. One study determined that the entire Great Lakes fishing industry is valued at $6.89 billion, supporting 75,000 sport fishing-related and 9,000 commercial fishing-related jobs [8].

- Ohio's $600 million Lake Erie sport fishery lost 50 to 65 percent of its value between 1985 and 1995. Possible reasons include an above-capacity walleye population in early 1982, a rapidly growing white perch population from 1985 to 1993, and the zebra mussel [35].

- The annual estimated economic damage of the European green crab to shellfish production in the United States, including clams and oysters, is about $44 million [19].

Control and Management Efforts

Control activities, once introduced, are mostly site-specific, and several control methods are usually necessary, resulting in extensive direct expenditures. The U.S. General Accounting Office recently surveyed 10 federal departments to determine national expenditures on aquatic and terrestrial NIS activities [67]. Eight agencies on the Invasive Species Council collectively spent $513.9 million in 1999 and $631.5 million in 2000 for the management and control of NIS. The following studies and anecdotes shed some light on associated costs.

- The U.S. Fish and Wildlife Service has developed a detailed management strategy to control the spread of zebra mussel and other NIS. The cost of this strategy is proposed at $5 million over 5 years [46].

- Control and research costs for the Chinese mitten crab included $1 million in federal funds from 2000 to 2001 [10].

- Control and monitoring costs for the Mediterranean green seaweed in southern California were $2.33 million from 2000 to 2001 [10].

- The 11-year costs of a ruffe control program in the Great Lakes are an estimated $12 million [41].

Socioeconomic Impacts

The introduction of NIS via ballast water discharge and subsequent invasions of native aquatic ecosystems have demonstrable adverse effects on economic systems and potential impacts on public health. NIS control programs can result in long-term financial burdens, as researchers believe that once an aquatic NIS becomes established, eradication is almost impossible in large aquatic ecosystems [45].

Studies of the socioeconomic impacts of aquatic NIS introductions are difficult to perform and currently sparse [54]. As noted previously, in-depth study of the economic impacts of bioinvasions attributable to ballast water discharge center primarily around one species, the zebra mussel. While the introduction of bacteria and viruses through ballast water is a growing concern, potential public health impacts remain virtually unexplored by scientists [61, 62], though a host of microorganisms have been found in ballast water [15, 40, 57, 62, 73].

Most available studies and anecdotes attempt to address the costs associated with established economic systems—the inherent value of native ecosystems and biodiversity, the value of coastal ecosystem services such as erosion control, storm surge barriers, and nursery habitat, as well as aesthetic, cultural, and social attributes are not addressed in the available literature. For instance, studies have not attempted to quantify the future economic costs of declines in fish species that do not constitute a commercial or recreational fishery. Likewise, no special attention has been given to the impact of NIS to cultural and social systems. For example, a bioinvasion by a nonindigenous fish species could force local fishermen to seek other employment, eventually altering the social culture of the region as work shifts away from traditional occupations.

Framework for Quantification and Model Inputs

The estimation of annual benefits proved challenging. Part of that challenge involves characterizing the uncertainty that surrounds each of the input to our benefits model, described in the following sections. Uncertainty modeling, such as Monte Carlo analysis, would require us to make assumptions, such as the shape of a distribution curve, that cannot be made at this time given the current state of the science. We could make the necessary assumptions to simulate through Monte Carlo analysis, but we would still not be able to make statements concerning the nature of uncertainty, and interpretation of our results might be overconfident. For these reasons, we chose a simple, straightforward, and transparent framework that provides the magnitude of benefits we could expect to see with this rulemaking.

The benefit calculation is based on a model of vessel arrivals coming into U.S. ports, and the decrease in the opportunity, as a result of mandatory BWM, for these vessels to carry out ballast water discharge that would cause a bioinvasion. This framework accounts for the probability of exchange based on the analysis presented in the derivation of national cost of the proposed rule. Since we have now estimated the annual number of arrivals, the average number of exchanges, and the probability that exchange will be conducted, we can estimate the number of invasions that will be avoided annually under the proposed rule.

Benefit Calculations

In this analysis, we estimate the number of "inoculations" under the baseline case (current regulatory regime) and the post-rule case (promulgation of mandatory BWM practices). "Inoculations" are the number of successful injections of nonindigenous organisms from arrivals into U.S. ports. In other words, an inoculation means live organisms have survived entry into the ballast tank through the pumping system, the transit from the departure port to the arrival port, and discharge into the waters of the receiving port. It is important to remember that this rule is addressing only those inoculations from vessels arriving from foreign ports. Inoculations from vessels arriving from other domestic ports would not be prevented, as vessels in coastwise trade would not have the opportunity to conduct ballast exchange since they do not transit more than 200 miles from shore.

We estimate annual inoculations using the following.

- Vessel type and transit track
- Probability of exchange under the current regulatory regime (baseline)
- Probability of exchange in the transit track given weather conditions and type of vessel (following promulgation of the BWM rule)
- Estimated effectiveness of exchange, which varies by the type of exchange conducted (sequential or flow-through)
- Number of arrivals by vessel type and transit track

We estimate annual inoculations using the average of the results from 1999 and 2000.

Vessel type, transit track, arrivals, and probability of exchange in a transit track post-rulemaking are taken directly from the estimates presented in the cost analysis. Our baseline probability of exchange comes from two sources: the Coast Guard's 2001 Report to Congress on the national, voluntary program for exchange [63] and from a 2003 report from California on its mandatory requirements [23]. Using the limited data from the Report to Congress, we estimated approximately 5 percent of arrivals have had ballast exchange prior to entering a U.S. port. All West Coast states (California, Oregon, Washington) have mandatory exchange programs, and the report from California estimates that approximately 25 percent of arrivals have had some degree of ballast exchange prior to entry in California ports. These 5 and 25 percent values are percentages of total arrivals reporting that they conducted ballast water exchange. Many other vessels reported no intention to discharge ballast. Because these vessels may visit subsequent U.S. ports where they may discharge some ballast before going outside 200 miles from shore, they were included among the vessels at risk to introduce NIS. For the baseline, therefore, we use a probability of exchange of 25 percent for arrivals to the West Coast from East Asia (track 5), Southeast Asia (track 6), and West Africa (track 11). For all other transit tracks, we use a 5 percent probability of exchange.

For exchange effectiveness, we assumed that a flow-through exchange would be 70 percent effective in removing organisms from ballast tanks [23]. Bulkers, tankers, and gas carriers conduct flow-through exchanges. All other vessels conduct sequential exchanges, which we assumed would be 90 percent effective [23].

The total number of arrivals is derived from the Coast Guard's MSMS database. There are approximately 34,700 arrivals from foreign ports into U.S. ports annually, including both foreign and domestic arrivals.

Before mandatory BWM, the baseline, annual inoculations can be calculated as—

1 - (probability of exchange × effectiveness of exchange) = probability of inoculation per arrival

and

Probability of inoculation per arrival × annual arrivals = annual inoculations

Annual inoculations are calculated for each vessel type by track, for the baseline and post-rule conditions. For example, 1999 BULK1 inoculations from Northern Europe to the East Coast (track 1) under the current baseline would be—

$1 - (5\% \times 70\%) = 97\%$

and

$97\% \times 221$ arrivals = 213 inoculations.

1999 BULK1 inoculations from East Asia to the West Coast (track 5) under the current baseline would be—

$1 - (25\% \times 70\%) = 83\%$

and

$83\% \times 860$ arrivals = 709 inoculations.

These calculations are repeated for all vessel types for all transit tracks. Table 8 presents the baseline number of arrivals and inoculations. For more detail on benefit calculations see Appendix D. On average, there are 34,700 arrivals annually affected by the rule (vessels arriving from foreign ports that have ballast tanks), and on average 97 percent of these arrivals result in inoculation.

Table 8.

Baseline Annual Inoculations

Measure	1999	2000	Average
Arrivals from vessels subject to proposed rule	33,959	35,423	34,691
Baseline inoculations from vessels subject to proposed rule	32,435	35,045	33,740
Baseline percent of arrivals with inoculations	96%	99%	97%

Annual inoculations are then calculated for each vessel type by track for the post-rule condition. Again using BULK1, 1999 BULK1 inoculations from Northern Europe to the East Coast (track 1) under the proposed rule, where BWM would be mandatory, would be—

$1 - (57\% \times 70\%) = 60\%$

and

$60\% \times 221$ arrivals = 132 inoculations.

1999 BULK1 inoculations from East Asia to the West Coast (track 5) under the proposed rule would be—

$1 - (61\% \times 70\%) = 57\%$

and

$57\% \times 860$ arrivals = 494 inoculations.

These calculations are repeated for all vessel types for all transit tracks. Table 9 presents the number of arrivals and inoculations following promulgation of the proposed rule. As shown, following the rule, there are approximately 24,600 arrivals that result in inoculation.

Table 9.

Post-rule Annual Inoculations

Measure	1999	2000	Average
Arrivals from vessels subject to proposed rule	33,959	35,423	34,691
Post-rule inoculations from vessels subject to proposed rule	24,067	25,121	24,594
Post-rule percent of arrivals with inoculations	71%	71%	71%

Table 10 shows the net reduction of inoculations from the baseline to post-rule. As shown, we expect inoculations to decrease by 26 percent as a result of the proposed rule.

Table 10.

Reduction of Inoculations from the Baseline to the Proposed Rule

Measure	1999	2000	Average
Total arrivals from vessels subject to proposed rule	33,959	35,423	34,691
Baseline inoculations	32,435	35,045	33,740
Post-rule inoculations	24,067	25,121	24,594
Net reduction	(8,368)	(9,924)	(9,146)
Baseline percent of arrivals with inoculations	96%	99%	97%
Post-rule percent of arrivals with inoculations	71%	71%	71%
Net reduction	25%	28%	26%

Once the receiving waters have been inoculated, the probability is very low that any of the organisms in the discharge will become an invasive species. As described previously, invasion biology is startlingly complex and estimates regarding probable invasions carry high degrees of variance and uncertainty. For this analysis, we used the "rule of 10s" to estimate the number of annual inoculations that would result in a nuisance species invasion. Using invasion probabilities discussed in bioinvasion literature, we estimate a 10 percent probability that the organisms in ballast water will survive inoculation [70]. We estimate that 10 percent of those organisms that survive inoculation will become established and proliferate. We then estimate that 10 percent of those organisms that proliferate will become an invasive species. For a single inoculation, therefore, there is a 1 in 1,000 chance an organism in the inoculation will become an invasive nuisance species.

Based on the "rule of 10s" and our above analysis, we would estimate a reduced number of inoculations that would result in invasions. Table 11 presents the number of inoculations with invasive organisms that will be reduced as a result of the proposed rule. As shown, we estimate the proposed rule will result in approximately 10 fewer inoculations that would result in an invasive species invasion. *Our analysis does not imply that we are preventing 10 invasive species annually.* Rather, we estimate that we are preventing 10 inoculations where an invasive species may become established.

Table 11.
Annual Inoculations, Survivals, Proliferations, and Invasions Baseline and Post-Rule

Measure	1999	2000	Average
Baseline			
Inoculations	32,435	35,045	33,740
Inoculations that result in survival	3,244	3,504	3,374
Inoculations that result in proliferation	324	350	337
Inoculations that result in invasion	32	35	34
Post-rule			
Inoculations	24,067	25,121	24,594
Inoculations that result in survival	2,407	2,512	2,459
Inoculations that result in proliferation	241	251	246
Inoculations that result in invasion	24	25	25
Change			
Inoculations	(8,368)	(9,923)	(9,146)
Inoculations that result in survival	(837)	(992)	(915)
Inoculations that result in proliferation	(84)	(99)	(91)
Inoculations that result in invasion	(8)	(10)	(9)

For several reasons, we did not assign a dollar value to the estimated reduction in inoculations that could occur as a result of the proposed rule. First, our estimate carry a high degree of uncertainty that we are unable to address given the state-of-the-science as it is today. Second, while many studies have examined the damages from invasive species, these studies have been limited in their scope (e.g., one species, one region), have estimated only readily quantifiable effects (e.g., clogged intake pipes, closed fishery), and have examined primarily "high consequence" or "high visibility" species (e.g., zebra mussels, Asian clams). Third, while damage to infrastructure and fisheries is important to consider and quantify, the "collapse" of ecosystems or the extinction of a species may be even more important. The monetization of ecosystem damages is especially problematic. As one study states: "Economic projections do not account well for those future events that have a low probability of occurring but will cause high impact if they do occur. Unfortunately, many potential NIS problems fit this description. Scientific ignorance, long time lags, and cumulative, sometimes irreversible, effects confound the accounting" [64].

Results and Interpretation

Quantifying the benefits associated with mandatory ballast water management as described in the proposed rule is a complex task. The model we have constructed reflects a strong dependence of the benefits on the population of vessels conducting exchange as well as assumptions concerning the effectiveness of ballast water exchange. In addition, a careful review of the assumptions reveals we have equated the probability of a shipload of ballast water discharged into U.S. waters with viable organisms with the inoculation of a species into the receiving waters. Though this is a gross approximation, there is limited information published concerning the number and type of viable organisms discharged from ballast water. Most studies sample ballast water prior to discharge, that is, while it is still in the tanks. The number and distribution of organisms that survive the discharge from the ship can be assumed to be different than the number and distribution of those in ballast tanks. Furthermore, though as many as 12,000 organisms have been identified in just one vessel [32], the species represented are not unique from one vessel to the next. Finally, there are indications in the literature, that the number and type of surviving organisms following an ocean transit is partly dependent on the length of the transit, with fewer organisms surviving longer transits.

We made additional generalizations concerning exchange. As with the cost model, we considered each arriving vessel as a candidate to discharge ballast water into the United States. Arguably, many vessels will be offloading more cargo in U.S. ports than they will load, and ballast water will not need to be discharged. However, with many vessels making multiple port calls each time they enter the U.S. EEZ, we made the simplifying assumption that all vessels may discharge some ballast water. We also made gross assumptions concerning effectiveness of exchange. As described, we used 70 percent as the effectiveness for flow-through exchanges, and 90 percent for sequential exchange. In actuality, there is a wide range of estimates of the effectiveness of exchange, which is influenced by ballast tank configurations, differences in temperature and salinity between the coastal ballast water and the mid-ocean water, the presence and abundance of sediments in tanks, and so forth. We are also unable to capture the effect of changes in the ecology of receiving waters on the probability an inoculation would become an invasion.

The "rule of 10s" is an oversimplification of a very complex problem. We used the rule because its simplicity and transparence are compelling. It has also produced results consistent with other studies addressing the rate of invasions. It remains, however, a blunt instrument for analyzing a sensitive scientific issue. To date, there is no national estimate of the rate of aquatic NIS, and we cannot compare our baseline invasion estimate to other, more limited estimates regarding invasions. Our findings are broadly consistent, however, with other estimates of the rate of NIS invasions. One study finds that in the San Francisco Bay and Delta, invasions have increased from one new species every 55 weeks (1851–1960) to one new species every 14 weeks (1961–1995) [18]. Another study posits that invasion rates may have increased in the San Francisco Bay and the Great Lakes over the past several decades [49]. Finally, some researchers believe that the increase of initial invasions is best described by an exponential function [61]. Use of our simple methodology would imply that an invasion occurs somewhere in the United States about twice every 3 weeks.

The hypothesized exponential increase in invasions makes our estimates all the more uncertain, though we do not believe they are unreasonable given our current understanding of invasion biology. With an appreciation of the limitations of our analysis as presented above, we find it realistic to expect that mandatory BWM could reduce the amount of ballast water containing organisms discharged into U.S. waters by vessels arriving from outside the EEZ by approximately 25 percent.

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4. Initial Regulatory Flexibility Act Analysis

In accordance with the Regulatory Flexibility Act (RFA), the Coast Guard prepared an Initial Regulatory Flexibility Analysis (IRFA) that examines the impacts of the proposed rule on small entities (5 USC 601 *et seq.*). A small entity may be—

- A small business, defined as any independently owned and operated business not dominant in its field that qualifies as a small business per the Small Business Act. (15 USC 632)
- A small not-for-profit organization
- A small governmental jurisdiction (locality with fewer than 50,000 people)

Entities affected by the proposed rule are owners and operators of vessels equipped with ballast tanks and entering U.S. waters from outside the EEZ. For the purpose of the IRFA, only vessels owned by U.S. companies are included. We determined which entities were small based on the North American Industry Classification System (NAICS) and the *Reference USA* database available online [72]. In some cases, businesses are small based on the number of employees, though many businesses are classified based on their annual revenues. We found 10 companies owning U.S. flagged vessels that are small businesses and will be affected by the proposed rule.

This IRFA addresses the following:

- The reason the agency is considering this action
- The objectives of and legal basis for the proposed rule
- The number and types of small entities to which the rule will apply
- Projected reporting, recordkeeping and other compliance requirements of the proposed rule, including the classes of small entities that will be subject to the requirements and the type of professional skills necessary for the preparation of the reports and records
- Other relevant Federal rules that may duplicate, overlap, or conflict with the proposed rule
- Significant alternatives to the component under consideration that accomplish the stated objectives of applicable statutes and may minimize any significant economic impact of the proposed rule on small entities

Many of these issues have been discussed at length in other sections of this Regulatory Evaluation. We broadly address some of these issues here and refer the reader to applicable sections where more detail can be found.

Reason for Agency Action

The purpose of the proposed rule is to reduce the amount of ballast water discharged from ships entering the United States from foreign ports and coastal areas into U.S. waters. More detail can be found in Chapter 1.

Objective and Legal Basis

The legal basis for the proposed rule is the National Invasive Species Act (NISA) [Pub. L. 104-3321] enacted by Congress on October 26, 1996. The purpose of this law is to address the growing threat posed by aquatic NIS. The proposed rule is in direct response to the stated intent of Congress for the creation of a mandatory BWM program in the event the voluntary program failed to meet its objectives. More detail can be found in Chapter 1.

Number and Types of Small Entities Affected

Of the affected population, we estimate that 21 U.S. vessels of the 171 total, are owned by 10 small businesses. Approximately 35 large companies own the remaining 150 U.S. flagged vessels.

We estimate all vessels will choose the alternative of conducting a mid-ocean ballast water exchange. The cost of complying with the proposed rule is the cost of exchanges performed by the vessel added to the cost of additional maintenance required for the ballast water pumping system. The cost per exchange is a function of vessel type. Each vessel's costs will be a function of the cost of exchange for that vessel type multiplied by the number of trips into U.S. waters from outside the U.S. EEZ. Thus, the annual impact on the revenue for a small business will vary with the number of entries the vessel makes from outside the U.S. EEZ. In order to estimate the upper bound of that impact, we calculated the cost of exchange for the maximum number of exchanges possible for the years 1999 and 2000. We then assumed that weather conditions and transit tracks allowed exchanges for all of these entries. The number of vessels owned by each small business is multiplied by the number of exchanges performed, which is then multiplied by the cost of exchange for the particular vessel type and added to the maintenance cost of 10 percent of the capital cost of the ballast pump for the annual cost of the rule. Of the 10 small businesses that own vessels affected by the rule, we found revenue for 9. For the remaining company where no revenue information was available, we assumed revenue of $1 million for the purposes of the analysis. Table 12 gives the effect of the rule on the average annual revenues for the small business affected. For more detailed information, refer to Appendix E.

Table 12.
Effect of BWM on Average Annual Revenue for Small Business Entities Owning U.S.-Flagged Vessels

Percent of Annual Revenue that is BWM Rule Cost	Total Small Entities per Impact Category
0–3%	8
3–5%	2
> 5%	0
Total	10

Types of Entities Affected by the Proposed Rule

We classified small businesses by NAICS code for those businesses that had revenue information. The types of small entities that will be affected by the proposed rule are presented in Table 13.

Table 13.
NAICS Codes, Descriptions, Definitions and Number and Percent of Small Businesses for U.S.-Flagged Vessels

NAICS	Description	Small Business Definition	Number of Small Entities with Known NAICS Codes	Percent of Small Entities with Known NAICS Codes
484230	Other specialized trucking-long distance	<$12.5M ann rev.	2	20%
483211	Inland water freight transportation	<500 employees	1	10%
487210	Scenic and sightseeing transportation-water	<500 employees	2	20%
488510	Freight transportation arrangement	<$12.5M ann rev.	1	10%
522110	Commercial banking	<$100M ann rev.	1	10%
523991	Trust, fiduciary, and trust activities	<$100M ann rev.	1	10%
541614	Process and logistics consulting services	<$3.5M ann rev.	1	10%

Reporting and Recordkeeping

The proposed rule will require additional reporting or recordkeeping for vessel owners or operators. Each vessel will require a BWM plan, which is a one-time cost that will be incurred during implementation of the rule. This plan is expected to take 8 hours to prepare at a cost of $100 per hour for a total of $800. This should not impose a detrimental burden to small businesses.

Other Federal Rules

The proposed rule does not duplicated, overlap, or conflict with any other Federal requirements.

Regulatory Alternatives

Ballast water management options available to small business owners are identical in cost and accessibility to those available to other commercial entities. Presently, there are no onboard ballast water treatment systems, nor shore-side discharge facilities approved for the removal of NIS from ballast water. As a result, small businesses presently have two options at their disposal for ballast water management. Some vessels may elect to retain ballast water on board as a principal BWM strategy. This option is realistic for all vessels planning cargo operations characterized by greater tonnages of cargo offloaded to U.S. ports versus the amount of cargo loaded. If this condition is met, the company can choose to retain ballast water on board and incur little if any economic impacts as a result of the proposed rule. However, if cargo operations are such that extensive transfer of ballast water within the vessel is required to make the necessary adjustments to maintain list, trim, and stability as a result of cargo operations, it is possible the operational costs of this option would approach the costs of ballast water exchange.

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Appendix A

Comparison of Ballast Water Capacity Estimates from Various Sources

Appendix A: Comparison of Ballast Water Capacity Estimates from Various Sources

	NBIC		Lloyd's Register		Literature
Vessel Category	Sample Size	Capacity (m^3)	Sample Size	Capacity (m^3)	Capacity (m^3)
TANK1	36	6,427	236	4,692	5,517
TANK2	202	31,532	570	32,097	30,863
TANK3	60	54,140	164	53,507	61,602
TANK4	63	89,241	269	97,170	125,000
TANK5	7	92,995	9	73,542	-
BULK1	689	17,684	193	14,837	14,500
BULK2	360	35,592	175	30,303	36,500
BULK3	81	62,895	166	62,682	65,000
PASS	52	2,644	-	-	-
GAS	62	11,577	154	21,788	40,000
CHEM	118	10,703	479	9,478	-
RORO	169	7,684	12	3,694	5,500
COMB	93	7,319	2	1,258	6,695
GENCARG	541	4,529	89	5,938	6,854
FEEDER	4	2,948	3	4,076	3,400
FEEDERMAX	15	3,665	1	4,000	-
HANDY	102	7,996	10	7,706	8,370
SUBPANAMAX	101	13,857	11	10,230	20,000
PANAMAX	131	17,241	6	16,570	13,000
POSTPANAMAX	59	19,063	1	26,269	20,000

Appendix B

Probabilities of Exchange Based on Sea States

Appendix B: Probabilities of Exchange Based on Sea States

6 meter and less wave height probability for ballast water exchange (GENCARG, PASS, COMB, RORO, CHEM, all container ships)

	Track Description	Sea Area	Probability of Exchange 0-1m	1-2m	2-3m	3-4m	4-5m	5-6m	Total	Avg. Probability
1	Northern Europe to East Coast	16	57	216	255	197	124	70	919	93.40%
		24	83	264	269	181	101	51	949	
2	Mediterranean to East Coast	24	83	264	269	181	101	51	949	95.80%
		25	74	263	291	195	100	44	967	
3	Northern Europe to Gulf of Mexico and Caribbean	16	57	216	255	197	124	70	919	95.33%
		24	83	264	269	181	101	51	949	
		33	161	412	265	107	36	11	992	
4	Mediterranean to Gulf of Mexcio and Caribbean	24	83	264	269	181	101	51	949	94.33%
		33	161	412	265	107	36	11	992	
		34	109	268	296	143	55	18	889	
5	East Asia to West Coast	21	74	267	289	192	99	45	966	95.55%
		30	81	244	261	189	111	59	945	
6	Southeast Asia to West Coast	31	80	354	311	158	63	22	988	98.60%
		43	93	307	289	174	83	34	980	
		52	200	376	248	111	42	15	992	
7	South America to East Coast	33	161	412	265	107	36	11	992	99.53%
		48	66	377	349	151	44	9	996	
		56	65	417	359	126	27	4	998	
8	West Africa to East Coast	34	109	268	296	143	55	18	889	97.03%
		48	66	377	349	151	44	9	996	
		57	105	480	313	86	14	2	1000	
		68	71	405	356	129	30	5	996	
9	Central America to Pacific Islands	44	47	310	353	193	71	20	994	99.50%
		45	55	363	356	161	49	12	996	
10	East Asia to Alaska	13	63	238	276	201	114	57	949	95.80%
		30	81	244	261	189	111	59	945	
		42	158	362	257	127	54	22	980	
11	West Africa to Pacific Islands	48	66	377	349	151	44	9	996	99.70%
		49	72	388	349	143	38	8	998	
13	Southeast/East Asia to Pacific Islands	52	200	376	248	111	42	15	992	99.50%
		63	226	450	234	70	16	3	999	

3 meter and less wave height probability for ballast water exchange (bulkers, tankers, GAS)

		Probability of Exchange				
	Sea Area	0-1m	1-2m	2-3m	Total	Avg. Probability
1 Northern Europe to East Coast	16	57	216	255	528	**57.20%**
	24	83	264	269	616	
2 Mediterranean to East Coast	24	83	264	269	616	**62.20%**
	25	74	263	291	628	
3 Northern Europe to Gulf of Mexico and Caribbean	16	57	216	255	528	**66.07%**
	24	83	264	269	616	
	33	161	412	265	838	
4 Mediterranean to Gulf of Mexcio and Caribbean	24	83	264	269	616	**70.90%**
	33	161	412	265	838	
	34	109	268	296	673	
5 East Asia to West Coast	21	74	267	289	630	**60.80%**
	30	81	244	261	586	
6 Southeast Asia to West Coast	31	80	354	311	745	**75.27%**
	43	93	307	289	689	
	52	200	376	248	824	
7 South America to East Coast	33	161	412	265	838	**82.37%**
	48	66	377	349	792	
	56	65	417	359	841	
8 West Africa to East Coast	34	109	268	296	673	**79.88%**
	48	66	377	349	792	
	57	105	480	313	898	
	68	71	405	356	832	
9 Central America to Pacific Islands	44	47	310	353	710	**74.20%**
	45	55	363	356	774	
10 East Asia to Alaska	13	63	238	276	577	**64.67%**
	30	81	244	261	586	
	42	158	362	257	777	
11 West Africa to Pacific Islands	48	66	377	349	792	**80.05%**
	49	72	388	349	809	
13 Southeast/East Asia to Pacific Islands	52	200	376	248	824	**86.70%**
	63	226	450	234	910	

Appendix C

Calculations of Cost

Appendix C: Calculations of Cost

Cost Models by Vessel Type

The following tables summarize cost data for 1999 and 2000 arrivals by vessel type. Each sheet contains the cost information for one vessel type for one year. There are then two sheets for each vessel type. The terminology used on the cost models is discussed below using the model for BULK1 and 1999 arrivals as an example.

Arrivals are arrivals into U.S. ports. A *NonEEZ Arrival* is an arrival into a U.S. port that was determined to be from outside the U.S. EEZ. *Foreign* and *Domestic* indicate the flag of the vessel, with Domestic vessels synonymous with U.S.-flagged vessels. Not all U.S.-flagged vessels are owned by U.S. companies, nor are all foreign flagged vessels owned by other-than-U.S. companies. *Arrival Data* is the arrival data from the Marine Safety Management System (MSMS).

Number BULK1 1999 is the number of vessels that made arrivals to U.S. ports in 1999, were in bulk service and less than 50,000 DWT. The *Number and Percent in nonEEZ* tracks is the total number of vessels that made at least one transit in a track that went more than 200 nautical miles from shore and thus were able to conduct at least one exchange for the year. These vessels were assumed to incur the maintenance cost associated with exchanges.

Estimated annual exchanges are the total number of arrivals from outside the U.S. EEZ multiplied by the probability that weather and transit track would permit an exchange.

In reading the table, *Tracks* are the 13 transit tracks that indicate the geographic origin and destination of a voyage. Moving across the first line of the BULK1 table, *5* percent of the 4,511 NonEEZ arrivals traveled track 1, approximately *221* arrivals. The *Probability of exchange in track* means that *57.2%* of the time, wave heights in track 1 would have been less than the maximum for a bulk carrier to conduct an exchange. The *total ballast capacity* is an average ballast water capacity for all BULK1 carriers in cubic meters, 17,700 m^3. The value for *Volumes per ballast exchange* equal 3 indicates that BULK1 carriers were assumed to conduct a flow-through exchange, requiring three complete volumes of the ship's ballast to be pumped. The *Cost per m^3 exchanged* is \$0.013 is constant for all vessel types. *Cost per exchange* is the *Total ballast capacity*, multiplied by the *Volumes per ballast exchanged* multiplied by the *Cost per exchange* and is \$690 for BULK1 vessels. The number of *Bounces in track* multiplied by the *Probability of exchange in track* multiplied by the *Cost per exchange* then yields the *Total cost*. For track 1, *221* bounces times *57.2 percent* times *\$690* equals approximately *\$87,200* for all exchanges of BULK1 vessels for 1999 in the route from Northern Europe to the U.S. East Coast. For all tables, the table entries as shown may not calculate to the total shown due to independent rounding.

The sum of all BULK1 exchange costs across all transit tracks is *\$1,117,458*. The *Annual maintenance* is the number of vessels in nonEEZ tracks multiplied by the estimated annual cost of maintenance for BULK1 vessels (\$2,500, not shown). *1,384* BULK1 vessels times \$2,500 equals *\$3,459,227*. Adding the *Exchange* cost to the *Annual maintenance* gives the *Total cost* of the proposed rule for all BULK1 vessels, *\$4,576,685*.

The following pages contain the tables of cost data for the various vessel types.

BULK1 Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	8,118	8,071	47	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	4,511	4,476	35	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number BULK1 1999	1,756	1,750	6	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	79%			*Source: NVMC data*
Number in nonEEZ tracks	1,384			
Estimated annual exchanges		1,619		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	5%	221	57.2%	17,700	3	$ 0.013	$ 690	$ 87,200
2	3%	157	62.2%	17,700	3	0.013	690	67,475
3	6%	276	66.1%	17,700	3	0.013	690	125,975
4	4%	201	70.9%	17,700	3	0.013	690	98,259
5	19%	860	60.8%	17,700	3	0.013	690	360,873
6	4%	188	75.3%	17,700	3	0.013	690	97,837
7	4%	199	82.4%	17,700	3	0.013	690	113,364
8	5%	213	79.9%	17,700	3	0.013	690	117,569
9	0%	1	74.2%	17,700	3	0.013	690	355
10	2%	70	64.7%	17,700	3	0.013	690	31,213
11	0%	1	80.1%	17,700	3	0.013	690	765
12	46%	2,096	0.0%	17,700	3	0.013	690	-
13	1%	28	86.7%	17,700	3	0.013	690	16,573
Total	100%	4,511					**Exchange**	**$ 1,117,458**
							Annual maintenance	**$ 3,459,227**
							Total cost	**$ 4,576,685**

BULK1 Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	7,597	7,548	49	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	4,843	4,798	45	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number BULK1 2000	1,779	1,773	6	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	79%			*Source: NVMC data*
Number in nonEEZ tracks	1,402			
Estimated annual exchanges		1,738		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	5%	237	57.2%	17,700	3	$ 0.013	$ 690	$ 93,618
2	3%	169	62.2%	17,700	3	0.013	690	72,442
3	6%	297	66.1%	17,700	3	0.013	690	135,247
4	4%	216	70.9%	17,700	3	0.013	690	105,491
5	19%	923	60.8%	17,700	3	0.013	690	387,433
6	4%	202	75.3%	17,700	3	0.013	690	105,037
7	4%	214	82.4%	17,700	3	0.013	690	121,707
8	5%	229	79.9%	17,700	3	0.013	690	126,221
9	0%	1	74.2%	17,700	3	0.013	690	381
10	2%	75	64.7%	17,700	3	0.013	690	33,510
11	0%	1	80.1%	17,700	3	0.013	690	821
12	46%	2,250	0.0%	17,700	3	0.013	690	-
13	1%	30	86.7%	17,700	3	0.013	690	17,793
Total	100%	4,843					**Exchange**	**$ 1,199,700**
							Annual maintenance	**$ 3,504,536**
							Total cost	**$ 4,704,236**

BULK2 Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	2,223	2,201	22	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	1,563	1,547	16	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number BULK2 1999	670	665	5	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	86%			*Source: NVMC data*
Number in nonEEZ tracks	576			
Estimated annual exchanges		699		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	4%	55	57.2%	35,600	3	$ 0.013	$ 1,388	$ 43,785
2	3%	39	62.2%	35,600	3	0.013	1,388	33,845
3	11%	174	66.1%	35,600	3	0.013	1,388	159,638
4	10%	154	70.9%	35,600	3	0.013	1,388	151,700
5	20%	310	60.8%	35,600	3	0.013	1,388	261,862
6	1%	15	75.3%	35,600	3	0.013	1,388	15,271
7	4%	68	82.4%	35,600	3	0.013	1,388	77,482
8	12%	183	79.9%	35,600	3	0.013	1,388	202,579
9	0%	-	74.2%	35,600	3	0.013	1,388	-
10	1%	16	64.7%	35,600	3	0.013	1,388	14,313
11	0%	1	80.1%	35,600	3	0.013	1,388	738
12	35%	541	0.0%	35,600	3	0.013	1,388	-
13	1%	8	86.7%	35,600	3	0.013	1,388	9,595
Total	100%	1,563					**Exchange**	**$ 970,810**
							Annual maintenance	**$ 1,727,500**
							Total cost	**$ 2,698,310**

BULK2 Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	2,110	2,090	20	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	1,595	1,579	16	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number BULK2 2000	701	696	5	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	86%			*Source: NVMC data*
Number in nonEEZ tracks	602			
Estimated annual exchanges		714		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	4%	56	57.2%	35,600	3	$ 0.013	$ 1,388	$ 44,681
2	3%	40	62.2%	35,600	3	0.013	1,388	34,538
3	11%	178	66.1%	35,600	3	0.013	1,388	162,906
4	10%	157	70.9%	35,600	3	0.013	1,388	154,806
5	20%	317	60.8%	35,600	3	0.013	1,388	267,223
6	1%	15	75.3%	35,600	3	0.013	1,388	15,584
7	4%	69	82.4%	35,600	3	0.013	1,388	79,069
8	12%	186	79.9%	35,600	3	0.013	1,388	206,727
9	0%	-	74.2%	35,600	3	0.013	1,388	-
10	1%	16	64.7%	35,600	3	0.013	1,388	14,606
11	0%	1	80.1%	35,600	3	0.013	1,388	753
12	35%	552	0.0%	35,600	3	0.013	1,388	-
13	1%	8	86.7%	35,600	3	0.013	1,388	9,792
Total	100%	1,595					**Exchange**	**$ 990,685**
							Annual maintenance	**$ 1,807,429**
							Total cost	**$ 2,798,114**

BULK3 Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	646	646	0	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	453	453	0	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number BULK3 1999	185	185	0	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	87%			*Source: NVMC data*
Number in nonEEZ tracks	161			

Estimated annual exchanges 212 *Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	18%	82	57.2%	63,000	3	$ 0.013	$ 2,457	$ 115,636
2	1%	6	62.2%	63,000	3	0.013	2,457	8,477
3	10%	46	66.1%	63,000	3	0.013	2,457	75,034
4	4%	18	70.9%	63,000	3	0.013	2,457	32,209
5	3%	16	60.8%	63,000	3	0.013	2,457	23,478
6	1%	3	75.3%	63,000	3	0.013	2,457	5,129
7	1%	5	82.4%	63,000	3	0.013	2,457	9,355
8	28%	128	79.9%	63,000	3	0.013	2,457	250,379
9	0%	-	74.2%	63,000	3	0.013	2,457	-
10	0%	-	64.7%	63,000	3	0.013	2,457	-
11	0%	-	80.1%	63,000	3	0.013	2,457	-
12	33%	150	0.0%	63,000	3	0.013	2,457	-
13	0%	-	86.7%	63,000	3	0.013	2,457	-
Total	100%	453					**Exchange**	**$ 519,697**
							Annual maintenance	**$ 564,158**
							Total cost	**$ 1,083,856**

BULK3 Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	596	596	0	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	419	419	0	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number BULK3 2000	141	141	0	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	87%			*Source: NVMC data*
Number in nonEEZ tracks	123			
Estimated annual exchanges		196		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	18%	76	57.2%	63,000	3	$ 0.013	$ 2,457	$ 106,957
2	1%	5	62.2%	63,000	3	0.013	2,457	7,841
3	10%	43	66.1%	63,000	3	0.013	2,457	69,403
4	4%	17	70.9%	63,000	3	0.013	2,457	29,792
5	3%	15	60.8%	63,000	3	0.013	2,457	21,716
6	1%	3	75.3%	63,000	3	0.013	2,457	4,744
7	1%	4	82.4%	63,000	3	0.013	2,457	8,653
8	28%	118	79.9%	63,000	3	0.013	2,457	231,586
9	0%	-	74.2%	63,000	3	0.013	2,457	-
10	0%	-	64.7%	63,000	3	0.013	2,457	-
11	0%	-	80.1%	63,000	3	0.013	2,457	-
12	33%	139	0.0%	63,000	3	0.013	2,457	-
13	0%	-	86.7%	63,000	3	0.013	2,457	-
Total	100%	419					**Exchange**	**$ 480,691**
							Annual maintenance	**$ 429,980**
							Total cost	**$ 910,671**

TANK1 Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	887	752	135	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	499	485	14	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number TANK1 1999	110	106	4	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	74%			*Source: NVMC data*
Number in nonEEZ tracks	81			
Estimated annual exchanges		152		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	3%	13	57.2%	6,400	3	$ 0.013	$ 250	$ 1,827
2	2%	12	62.2%	6,400	3	0.013	250	1,904
3	2%	11	66.1%	6,400	3	0.013	250	1,846
4	3%	14	70.9%	6,400	3	0.013	250	2,453
5	1%	5	60.8%	6,400	3	0.013	250	809
6	6%	31	75.3%	6,400	3	0.013	250	5,809
7	16%	79	82.4%	6,400	3	0.013	250	16,221
8	1%	7	79.9%	6,400	3	0.013	250	1,382
9	0%	-	74.2%	6,400	3	0.013	250	-
10	0%	1	64.7%	6,400	3	0.013	250	86
11	0%	-	80.1%	6,400	3	0.013	250	-
12	60%	301	0.0%	6,400	3	0.013	250	-
13	5%	26	86.7%	6,400	3	0.013	250	5,538
Total	100%	499					**Exchange**	**$ 37,874**
							Annual maintenance	**$ 202,358**
							Total cost	**$ 240,233**

TANK1 Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	944	853	91	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	601	576	25	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number TANK1 2000	128	125	3	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	74%			*Source: NVMC data*
Number in nonEEZ tracks	94			
Estimated annual exchanges		183		*Arrivals in track x probability of exchange in track*

Track	**Percent arrivals in track**	**Arrivals in track**	**Probability of exchange in track**	**Total ballast capacity (m^3)**	**Volumes per ballast exchange**	**Cost per m^3 exchanged**	**Cost per exchange**	**Total cost**
1	3%	15	57.2%	6,400	3	$ 0.013	$ 250	$ 2,200
2	2%	15	62.2%	6,400	3	0.013	250	2,293
3	2%	13	66.1%	6,400	3	0.013	250	2,224
4	3%	17	70.9%	6,400	3	0.013	250	2,954
5	1%	6	60.8%	6,400	3	0.013	250	974
6	6%	37	75.3%	6,400	3	0.013	250	6,996
7	16%	95	82.4%	6,400	3	0.013	250	19,537
8	1%	8	79.9%	6,400	3	0.013	250	1,664
9	0%	-	74.2%	6,400	3	0.013	250	-
10	0%	1	64.7%	6,400	3	0.013	250	104
11	0%	-	80.1%	6,400	3	0.013	250	-
12	60%	362	0.0%	6,400	3	0.013	250	-
13	5%	31	86.7%	6,400	3	0.013	250	6,670
Total	100%	601					**Exchange**	**$ 45,616**
							Annual maintenance	**$ 235,472**
							Total cost	**$ 281,088**

TANK2 Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	7,192	5,725	1467	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	3,833	3,315	518	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number TANK2 1999	509	475	34	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	80%			*Source: NVMC data*
Number in nonEEZ tracks	408			

Estimated annual exchanges 628 *Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	4%	168	57.2%	31,500	3	$ 0.013	$ 1,229	$ 118,070
2	1%	33	62.2%	31,500	3	0.013	1,229	24,977
3	5%	189	66.1%	31,500	3	0.013	1,229	153,594
4	2%	84	70.9%	31,500	3	0.013	1,229	72,925
5	1%	30	60.8%	31,500	3	0.013	1,229	22,702
6	2%	71	75.3%	31,500	3	0.013	1,229	65,221
7	4%	158	82.4%	31,500	3	0.013	1,229	159,574
8	3%	104	79.9%	31,500	3	0.013	1,229	101,851
9	0%	1	74.2%	31,500	3	0.013	1,229	1,045
10	0%	18	64.7%	31,500	3	0.013	1,229	14,123
11	0%	-	80.1%	31,500	3	0.013	1,229	-
12	77%	2,943	0.0%	31,500	3	0.013	1,229	-
13	1%	35	86.7%	31,500	3	0.013	1,229	37,259
Total	100%	3,833					**Exchange**	**$ 771,341**
							Annual maintenance	**$ 1,222,727**
							Total cost	**$ 1,994,068**

TANK2 Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	7,386	6,016	1370	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	4,271	3,704	567	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number TANK2 2000	555	521	34	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	80%			*Source: NVMC data*
Number in nonEEZ tracks	444			
Estimated annual exchanges		700		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	4%	187	57.2%	31,500	3	$ 0.013	$ 1,229	$ 131,562
2	1%	36	62.2%	31,500	3	0.013	1,229	27,831
3	5%	211	66.1%	31,500	3	0.013	1,229	171,145
4	2%	93	70.9%	31,500	3	0.013	1,229	81,258
5	1%	34	60.8%	31,500	3	0.013	1,229	25,296
6	2%	79	75.3%	31,500	3	0.013	1,229	72,674
7	4%	176	82.4%	31,500	3	0.013	1,229	177,808
8	3%	116	79.9%	31,500	3	0.013	1,229	113,490
9	0%	1	74.2%	31,500	3	0.013	1,229	1,165
10	0%	20	64.7%	31,500	3	0.013	1,229	15,737
11	0%	-	80.1%	31,500	3	0.013	1,229	-
12	77%	3,279	0.0%	31,500	3	0.013	1,229	-
13	1%	39	86.7%	31,500	3	0.013	1,229	41,516
Total	100%	4,271					**Exchange**	**$ 859,483**
							Annual maintenance	**$ 1,333,229**
							Total cost	**$ 2,192,711**

TANK3 Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	1,065	692	373	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	702	469	233	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number TANK3 1999	123	113	10	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	90%			*Source: NVMC data*
Number in nonEEZ tracks	111			

Estimated annual exchanges		298		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	9%	64	57.2%	54,100	3	$ 0.013	$ 2,110	$ 77,280
2	0%	3	62.2%	54,100	3	0.013	2,110	4,150
3	9%	61	66.1%	54,100	3	0.013	2,110	84,851
4	2%	11	70.9%	54,100	3	0.013	2,110	16,556
5	3%	19	60.8%	54,100	3	0.013	2,110	24,339
6	3%	21	75.3%	54,100	3	0.013	2,110	33,896
7	1%	4	82.4%	54,100	3	0.013	2,110	6,869
8	31%	217	79.9%	54,100	3	0.013	2,110	366,378
9	0%	-	74.2%	54,100	3	0.013	2,110	-
10	0%	2	64.7%	54,100	3	0.013	2,110	3,236
11	1%	4	80.1%	54,100	3	0.013	2,110	6,676
12	42%	293	0.0%	54,100	3	0.013	2,110	-
13	0%	2	86.7%	54,100	3	0.013	2,110	4,338
Total	100%	702					**Exchange**	**$ 628,570**
							Annual maintenance	**$ 387,450**
							Total cost	**$ 1,016,020**

TANK3 Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	874	651	223	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	702	490	212	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number TANK3 2000	124	118	6	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	90%			*Source: NVMC data*
Number in nonEEZ tracks	112			
Estimated annual exchanges		298		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	9%	64	57.2%	54,100	3	$ 0.013	$ 2,110	$ 77,280
2	0%	3	62.2%	54,100	3	0.013	2,110	4,150
3	9%	61	66.1%	54,100	3	0.013	2,110	84,851
4	2%	11	70.9%	54,100	3	0.013	2,110	16,556
5	3%	19	60.8%	54,100	3	0.013	2,110	24,339
6	3%	21	75.3%	54,100	3	0.013	2,110	33,896
7	1%	4	82.4%	54,100	3	0.013	2,110	6,869
8	31%	217	79.9%	54,100	3	0.013	2,110	366,378
9	0%	-	74.2%	54,100	3	0.013	2,110	-
10	0%	2	64.7%	54,100	3	0.013	2,110	3,236
11	1%	4	80.1%	54,100	3	0.013	2,110	6,676
12	42%	293	0.0%	54,100	3	0.013	2,110	-
13	0%	2	86.7%	54,100	3	0.013	2,110	4,338
Total	100%	702					**Exchange**	**$ 628,570**
							Annual maintenance	**$ 390,600**
							Total cost	**$ 1,019,170**

TANK4 Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	337	173	164	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	323	163	160	*Source: Arrival data 1999 (MSMS)*
	Total	Foreign	Domestic	
Number TANK4 1999	100	95	5	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	95%			*Source: NVMC data*
Number in nonEEZ tracks	95			
Estimated annual exchanges		219		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	1%	3	57.2%	89,200	3	$ 0.013	$ 3,479	$ 5,279
2	0%	-	62.2%	89,200	3	0.013	3,479	-
3	10%	32	66.1%	89,200	3	0.013	3,479	74,693
4	48%	157	70.9%	89,200	3	0.013	3,479	386,066
5	1%	4	60.8%	89,200	3	0.013	3,479	8,417
6	3%	9	75.3%	89,200	3	0.013	3,479	24,313
7	0%	1	82.4%	89,200	3	0.013	3,479	1,900
8	24%	78	79.9%	89,200	3	0.013	3,479	215,625
9	0%	-	74.2%	89,200	3	0.013	3,479	-
10	3%	9	64.7%	89,200	3	0.013	3,479	20,889
11	3%	9	80.1%	89,200	3	0.013	3,479	24,011
12	7%	22	0.0%	89,200	3	0.013	3,479	-
13	0%	-	86.7%	89,200	3	0.013	3,479	-
Total	100%	323					**Exchange**	**$ 761,193**
							Annual maintenance	**$ 523,964**
							Total cost	**$ 1,285,158**

TANK4 Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	386	210	176	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	347	183	164	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number TANK4 2000	117	111	6	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	95%			*Source: NVMC data*
Number in nonEEZ tracks	111			

Estimated annual exchanges		235		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	1%	3	57.2%	89,200	3	$ 0.013	$ 3,479	$ 5,671
2	0%	-	62.2%	89,200	3	0.013	3,479	-
3	10%	35	66.1%	89,200	3	0.013	3,479	80,243
4	48%	168	70.9%	89,200	3	0.013	3,479	414,752
5	1%	4	60.8%	89,200	3	0.013	3,479	9,042
6	3%	10	75.3%	89,200	3	0.013	3,479	26,119
7	0%	1	82.4%	89,200	3	0.013	3,479	2,042
8	24%	83	79.9%	89,200	3	0.013	3,479	231,647
9	0%	-	74.2%	89,200	3	0.013	3,479	-
10	3%	10	64.7%	89,200	3	0.013	3,479	22,441
11	3%	9	80.1%	89,200	3	0.013	3,479	25,795
12	7%	24	0.0%	89,200	3	0.013	3,479	-
13	0%	-	86.7%	89,200	3	0.013	3,479	-
Total	100%	347					**Exchange**	**$ 817,752**
							Annual maintenance	**$ 613,038**
							Total cost	**$ 1,430,791**

TANK5 Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	118	118	0	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	63	63	0	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number TANK5 1999	29	29	0	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	95%			*Source: NVMC data*
Number in nonEEZ tracks	28			
Estimated annual exchanges		45		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	0%	-	57.2%	93,000	3	$ 0.013	$ 3,627	$ -
2	0%	-	62.2%	93,000	3	0.013	3,627	-
3	0%	-	66.1%	93,000	3	0.013	3,627	-
4	75%	47	70.9%	93,000	3	0.013	3,627	120,769
5	0%	-	60.8%	93,000	3	0.013	3,627	-
6	0%	-	75.3%	93,000	3	0.013	3,627	-
7	0%	-	82.4%	93,000	3	0.013	3,627	-
8	18%	11	79.9%	93,000	3	0.013	3,627	33,185
9	0%	-	74.2%	93,000	3	0.013	3,627	-
10	0%	-	64.7%	93,000	3	0.013	3,627	-
11	5%	3	80.1%	93,000	3	0.013	3,627	9,977
12	2%	1	0.0%	93,000	3	0.013	3,627	-
13	0%	-	86.7%	93,000	3	0.013	3,627	-
Total	100%	63					**Exchange**	**$ 163,931**
							Annual maintenance	**$ 165,714**
							Total cost	**$ 329,645**

TANK5 Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	29	29	0	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	28	28	0	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number TANK5 2000	20	20	0	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	95%			*Source: NVMC data*
Number in nonEEZ tracks	19			
Estimated annual exchanges		20		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	0%	-	57.2%	93,000	3	$ 0.013	$ 3,627	$ -
2	0%	-	62.2%	93,000	3	0.013	3,627	-
3	0%	-	66.1%	93,000	3	0.013	3,627	-
4	75%	21	70.9%	93,000	3	0.013	3,627	53,675
5	0%	-	60.8%	93,000	3	0.013	3,627	-
6	0%	-	75.3%	93,000	3	0.013	3,627	-
7	0%	-	82.4%	93,000	3	0.013	3,627	-
8	18%	5	79.9%	93,000	3	0.013	3,627	14,749
9	0%	-	74.2%	93,000	3	0.013	3,627	-
10	0%	-	64.7%	93,000	3	0.013	3,627	-
11	5%	2	80.1%	93,000	3	0.013	3,627	4,434
12	2%	1	0.0%	93,000	3	0.013	3,627	-
13	0%	-	86.7%	93,000	3	0.013	3,627	-
Total	100%	28					**Exchange**	**$ 72,858**
							Annual maintenance	**$ 114,286**
							Total cost	**$ 187,144**

CHEM Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	4,822	4,648	174	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	2,150	2,150	0	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number CHEM 1999	496	480	16	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	78%			*Source: NVMC data*
Number in nonEEZ tracks	389			
Estimated annual exchanges		786		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	7%	148	93.4%	10,700	2	$ 0.013	$ 278	$ 38,573
2	2%	48	95.8%	10,700	2	0.013	278	12,677
3	8%	181	95.3%	10,700	2	0.013	278	48,120
4	3%	57	94.3%	10,700	2	0.013	278	14,899
5	5%	115	95.6%	10,700	2	0.013	278	30,691
6	3%	56	98.7%	10,700	2	0.013	278	15,478
7	5%	104	99.5%	10,700	2	0.013	278	28,891
8	4%	77	97.0%	10,700	2	0.013	278	20,708
9	0%	1	99.5%	10,700	2	0.013	278	319
10	0%	2	95.8%	10,700	2	0.013	278	511
11	0%	5	99.7%	10,700	2	0.013	278	1,383
12	62%	1,331	0.0%	10,700	2	0.013	278	-
13	1%	23	99.6%	10,700	2	0.013	278	6,480
Total	100%	2,150					**Exchange**	**$ 218,729**
							Annual maintenance	**$ 1,167,285**
							Total cost	**$ 1,386,014**

CHEM Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	5,780	5,000	780	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	2,749	2,590	159	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number CHEM 2000	517	500	17	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	78%			*Source: NVMC data*
Number in nonEEZ tracks	406			
Estimated annual exchanges		1,005		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	7%	190	93.4%	10,700	2	$ 0.013	$ 278	$ 49,319
2	2%	61	95.8%	10,700	2	0.013	278	16,209
3	8%	232	95.3%	10,700	2	0.013	278	61,526
4	3%	73	94.3%	10,700	2	0.013	278	19,049
5	5%	148	95.6%	10,700	2	0.013	278	39,242
6	3%	72	98.7%	10,700	2	0.013	278	19,790
7	5%	133	99.5%	10,700	2	0.013	278	36,940
8	4%	98	97.0%	10,700	2	0.013	278	26,477
9	0%	1	99.5%	10,700	2	0.013	278	407
10	0%	2	95.8%	10,700	2	0.013	278	654
11	0%	6	99.7%	10,700	2	0.013	278	1,768
12	62%	1,702	0.0%	10,700	2	0.013	278	-
13	1%	30	99.6%	10,700	2	0.013	278	8,286
Total	100%	2,749					**Exchange**	**$ 279,667**
							Annual maintenance	**$ 1,216,707**
							Total cost	**$ 1,496,374**

GAS Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Total arrivals	977	977	0	*Source: Arrival data 1999 (MSMS)*
NonEEZ arrivals	676	676	0	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number Gas 1999	160	160	0	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	74%			*Source: NVMC data*
Number in nonEEZ tracks	119			
Estimated annual exchanges		137		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	2%	16	57.2%	11,600	3	$ 0.013	$ 452	$ 4,091
2	1%	9	62.2%	11,600	3	0.013	452	2,669
3	9%	61	66.1%	11,600	3	0.013	452	18,334
4	4%	30	70.9%	11,600	3	0.013	452	9,736
5	2%	14	60.8%	11,600	3	0.013	452	3,827
6	1%	9	75.3%	11,600	3	0.013	452	3,015
7	1%	6	82.4%	11,600	3	0.013	452	2,121
8	3%	21	79.9%	11,600	3	0.013	452	7,541
9	0%	3	74.2%	11,600	3	0.013	452	849
10	4%	27	64.7%	11,600	3	0.013	452	7,955
11	0%	1	80.1%	11,600	3	0.013	452	229
12	70%	476	0.0%	11,600	3	0.013	452	-
13	1%	4	86.7%	11,600	3	0.013	452	1,488
Total	100%	676					**Exchange**	**$ 61,854**
							Annual maintenance	**$ 356,648**
							Total cost	**$ 418,502**

GAS Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Total arrivals	982	982	0	*Source: Arrival data 2000 (MSMS)*
NonEEZ arrivals	720	720	0	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number Gas 2000	180	180	0	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	74%			*Source: NVMC data*
Number in nonEEZ tracks	134			
Estimated annual exchanges		146		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	2%	17	57.2%	11,600	3	$ 0.013	$ 452	$ 4,357
2	1%	10	62.2%	11,600	3	0.013	452	2,843
3	9%	65	66.1%	11,600	3	0.013	452	19,527
4	4%	32	70.9%	11,600	3	0.013	452	10,370
5	2%	15	60.8%	11,600	3	0.013	452	4,076
6	1%	9	75.3%	11,600	3	0.013	452	3,211
7	1%	6	82.4%	11,600	3	0.013	452	2,259
8	3%	22	79.9%	11,600	3	0.013	452	8,032
9	0%	3	74.2%	11,600	3	0.013	452	904
10	4%	29	64.7%	11,600	3	0.013	452	8,473
11	0%	1	80.1%	11,600	3	0.013	452	244
12	70%	506	0.0%	11,600	3	0.013	452	-
13	1%	4	86.7%	11,600	3	0.013	452	1,585
Total	100%	720					**Exchange**	**$ 65,880**
							Annual maintenance	**$ 401,229**
							Total cost	**$ 467,109**

FEEDER Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	205	205	0	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	158	158	0	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number FEEDER 1999	17	17	0	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	70%			*Source: NVMC data*
Number in nonEEZ tracks	12			
Estimated annual exchanges		60		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	3%	5	93.4%	2,900	2	$ 0.013	$ 75	$ 386
2	0%	-	95.8%	2,900	2	0.013	75	-
3	0%	-	95.3%	2,900	2	0.013	75	-
4	0%	-	94.3%	2,900	2	0.013	75	-
5	2%	3	95.6%	2,900	2	0.013	75	197
6	0%	-	98.7%	2,900	2	0.013	75	-
7	2%	4	99.5%	2,900	2	0.013	75	274
8	0%	-	97.0%	2,900	2	0.013	75	-
9	1%	1	99.5%	2,900	2	0.013	75	69
10	0%	-	95.8%	2,900	2	0.013	75	-
11	0%	-	99.7%	2,900	2	0.013	75	-
12	61%	97	0.0%	2,900	2	0.013	75	-
13	31%	48	99.6%	2,900	2	0.013	75	3,633
Total	100%	158					**Exchange**	**$ 4,559**
							Annual maintenance	**$ 17,850**
							Total cost	**$ 22,409**

FEEDER Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Number Arrivals	131	131	0	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	109	109	0	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number FEEDER 2000	11	11	0	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	70%		0	*Source: NVMC data*
Number in nonEEZ tracks	8			

Estimated annual exchanges		42		*Arrivals in track x probability of exchange in track*

Track	**Percent arrivals in track**	**Arrivals in track**	**Probability of exchange in track**	**Total ballast capacity (m^3)**	**Volumes per ballast exchange**	**Cost per m^3 exchanged**	**Cost per exchange**	**Total cost**
1	3%	4	93.4%	2,900	2	$ 0.013	$ 75	$ 266
2	0%	-	95.8%	2,900	2	0.013	75	-
3	0%	-	95.3%	2,900	2	0.013	75	-
4	0%	-	94.3%	2,900	2	0.013	75	-
5	2%	2	95.6%	2,900	2	0.013	75	136
6	0%	-	98.7%	2,900	2	0.013	75	-
7	2%	3	99.5%	2,900	2	0.013	75	189
8	0%	-	97.0%	2,900	2	0.013	75	-
9	1%	1	99.5%	2,900	2	0.013	75	47
10	0%	-	95.8%	2,900	2	0.013	75	-
11	0%	-	99.7%	2,900	2	0.013	75	-
12	61%	67	0.0%	2,900	2	0.013	75	-
13	31%	33	99.6%	2,900	2	0.013	75	2,507
Total	100%	109					**Exchange**	**$ 3,145**
							Annual maintenance	**$ 11,550**
							Total cost	**$ 14,695**

FEEDERMAX Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	1,674	1,644	30	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	579	575	4	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number FEEDERMX 1999	72	71	1	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	33%			*Source: NVMC data*
Number in nonEEZ tracks	24			
Estimated annual exchanges		97		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	2%	9	93.4%	3,700	2	$ 0.013	$ 96	$ 796
2	0%	1	95.8%	3,700	2	0.013	96	74
3	2%	9	95.3%	3,700	2	0.013	96	813
4	0%	-	94.3%	3,700	2	0.013	96	-
5	1%	6	95.6%	3,700	2	0.013	96	593
6	3%	17	98.7%	3,700	2	0.013	96	1,568
7	6%	37	99.5%	3,700	2	0.013	96	3,511
8	0%	-	97.0%	3,700	2	0.013	96	-
9	0%	-	99.5%	3,700	2	0.013	96	-
10	0%	-	95.8%	3,700	2	0.013	96	-
11	0%	-	99.7%	3,700	2	0.013	96	-
12	83%	480	0.0%	3,700	2	0.013	96	-
13	4%	21	99.6%	3,700	2	0.013	96	2,007
Total	100%	579					**Exchange**	**$ 9,362**
							Annual maintenance	**$ 35,265**
							Total cost	**$ 44,627**

FEEDERMAX Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Number Arrivals	1,604	1,551	53	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	631	615	16	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number FEEDERMX 2000	58	56	2	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	33%			*Source: NVMC data*
Number in nonEEZ tracks	19			
Estimated annual exchanges		106		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	2%	10	93.4%	3,700	2	$ 0.013	$ 96	$ 868
2	0%	1	95.8%	3,700	2	0.013	96	81
3	2%	10	95.3%	3,700	2	0.013	96	886
4	0%	-	94.3%	3,700	2	0.013	96	-
5	1%	7	95.6%	3,700	2	0.013	96	646
6	3%	18	98.7%	3,700	2	0.013	96	1,709
7	6%	40	99.5%	3,700	2	0.013	96	3,826
8	0%	-	97.0%	3,700	2	0.013	96	-
9	0%	-	99.5%	3,700	2	0.013	96	-
10	0%	-	95.8%	3,700	2	0.013	96	-
11	0%	-	99.7%	3,700	2	0.013	96	-
12	83%	523	0.0%	3,700	2	0.013	96	-
13	4%	23	99.6%	3,700	2	0.013	96	2,187
Total	100%	631					**Exchange $**	**10,202**
							Annual maintenance $	**28,408**
							Total cost $	**38,611**

HANDY Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	4,093	3,263	830	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	1,848	1,323	525	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number HANDY 1999	272	245	27	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	76%			*Source: NVMC data*
Number in nonEEZ tracks	206			

Estimated annual exchanges		960		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	16%	301	93.4%	8,000	2	$ 0.013	$ 208	$ 58,463
2	4%	65	95.8%	8,000	2	0.013	208	13,031
3	5%	93	95.3%	8,000	2	0.013	208	18,490
4	2%	36	94.3%	8,000	2	0.013	208	7,010
5	13%	242	95.6%	8,000	2	0.013	208	48,136
6	8%	147	98.7%	8,000	2	0.013	208	30,072
7	2%	33	99.5%	8,000	2	0.013	208	6,895
8	3%	54	97.0%	8,000	2	0.013	208	10,876
9	0%	-	99.5%	8,000	2	0.013	208	-
10	0%	-	95.8%	8,000	2	0.013	208	-
11	0%	-	99.7%	8,000	2	0.013	208	-
12	46%	844	0.0%	8,000	2	0.013	208	-
13	2%	33	99.6%	8,000	2	0.013	208	6,770
Total	100%	1,848					**Exchange**	**$ 199,743**
							Annual maintenance	**$ 309,400**
							Total cost	**$ 509,143**

HANDY Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Number Arrivals	3,966	3,315	651	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	1,975	1,550	425	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number HANDY 2000	279	254	25	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	76%			*Source: NVMC data*
Number in nonEEZ tracks	212			
Estimated annual exchanges		1,026		*Arrivals in track x probability of exchange in track*

Track	**Percent arrivals in track**	**Arrivals in track**	**Probability of exchange in track**	**Total ballast capacity (m^3)**	**Volumes per ballast exchange**	**Cost per m^3 exchanged**	**Cost per exchange**	**Total cost**
1	16%	322	93.4%	8,000	2	$ 0.013	$ 208	$ 62,481
2	4%	70	95.8%	8,000	2	0.013	208	13,926
3	5%	100	95.3%	8,000	2	0.013	208	19,761
4	2%	38	94.3%	8,000	2	0.013	208	7,491
5	13%	259	95.6%	8,000	2	0.013	208	51,444
6	8%	157	98.7%	8,000	2	0.013	208	32,139
7	2%	36	99.5%	8,000	2	0.013	208	7,368
8	3%	58	97.0%	8,000	2	0.013	208	11,623
9	0%	-	99.5%	8,000	2	0.013	208	-
10	0%	-	95.8%	8,000	2	0.013	208	-
11	0%	-	99.7%	8,000	2	0.013	208	-
12	46%	902	0.0%	8,000	2	0.013	208	-
13	2%	35	99.6%	8,000	2	0.013	208	7,236
Total	100%	1,975					**Exchange**	**$ 213,470**
							Annual maintenance	**$ 317,363**
							Total cost	**$ 530,833**

SUBPANAMAX Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	3,824	3,402	422	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	1,426	1,174	252	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number SUBPMAX 1999	210	189	21	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	71%			*Source: NVMC data*
Number in nonEEZ tracks	149			
Estimated annual exchanges		764		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	23%	323	93.4%	13,900	2	$ 0.013	$ 361	$ 108,902
2	2%	31	95.8%	13,900	2	0.013	361	10,778
3	3%	49	95.3%	13,900	2	0.013	361	16,820
4	0%	5	94.3%	13,900	2	0.013	361	1,809
5	17%	242	95.6%	13,900	2	0.013	361	83,557
6	3%	42	98.7%	13,900	2	0.013	361	15,137
7	2%	22	99.5%	13,900	2	0.013	361	7,890
8	3%	40	97.0%	13,900	2	0.013	361	14,141
9	0%	-	99.5%	13,900	2	0.013	361	-
10	1%	9	95.8%	13,900	2	0.013	361	3,062
11	0%	-	99.7%	13,900	2	0.013	361	-
12	44%	624	0.0%	13,900	2	0.013	361	-
13	3%	39	99.6%	13,900	2	0.013	361	13,873
Total	100%	1,426					**Exchange**	**$ 275,969**
							Annual maintenance	**$ 298,876**
							Total cost	**$ 574,845**

SUBPANAMAX Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	Source: Bounce data 2000 (MSMS)
Number Arrivals	3,880	3,475	405	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	1,575	1,307	268	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	*Source: Bounce data 2000 (MSMS)*
Number SUBPMAX 2000	220	198	22	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	71%			
Number in nonEEZ tracks	157			

Estimated annual exchanges 843 *Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	23%	356	93.4%	13,900	2	$ 0.013	$ 361	$ 120,281
2	2%	34	95.8%	13,900	2	0.013	361	11,904
3	3%	54	95.3%	13,900	2	0.013	361	18,577
4	0%	6	94.3%	13,900	2	0.013	361	1,998
5	17%	267	95.6%	13,900	2	0.013	361	92,287
6	3%	47	98.7%	13,900	2	0.013	361	16,719
7	2%	24	99.5%	13,900	2	0.013	361	8,714
8	3%	45	97.0%	13,900	2	0.013	361	15,619
9	0%	-	99.5%	13,900	2	0.013	361	-
10	1%	10	95.8%	13,900	2	0.013	361	3,382
11	0%	-	99.7%	13,900	2	0.013	361	-
12	44%	689	0.0%	13,900	2	0.013	361	-
13	3%	43	99.6%	13,900	2	0.013	361	15,322
Total	100%	1,575					**Exchange**	**$ 304,804**
							Annual maintenance	**$ 313,109**
							Total cost	**$ 617,913**

PANAMAX Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	5,171	4,333	838	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	2,192	1,917	275	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number PANAMAX 1999	295	267	28	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	93%			*Source: NVMC data*
Number in nonEEZ tracks	275			

Estimated annual exchanges		1,362		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	18%	388	93.4%	17,200	2	$ 0.013	$ 447	$ 162,242
2	2%	42	95.8%	17,200	2	0.013	447	18,043
3	2%	52	95.3%	17,200	2	0.013	447	21,959
4	0%	6	94.3%	17,200	2	0.013	447	2,521
5	34%	738	95.6%	17,200	2	0.013	447	315,172
6	5%	100	98.7%	17,200	2	0.013	447	43,946
7	4%	90	99.5%	17,200	2	0.013	447	40,026
8	0%	-	97.0%	17,200	2	0.013	447	-
9	0%	-	99.5%	17,200	2	0.013	447	-
10	0%	7	95.8%	17,200	2	0.013	447	2,926
11	0%	0	99.7%	17,200	2	0.013	447	127
12	35%	765	0.0%	17,200	2	0.013	447	-
13	0%	5	99.6%	17,200	2	0.013	447	2,280
Total	100%	2,192					**Exchange**	**$ 609,241**
							Annual maintenance	**$ 550,117**
							Total cost	**$ 1,159,358**

PANAMAX Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Number Arrivals	4,164	3,391	773	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	1,805	1,554	251	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number PANAMAX 2000	270	241	29	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	93%			*Source: NVMC data*
Number in nonEEZ tracks	252			

Estimated annual exchanges		1,122		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	18%	320	93.4%	17,200	2	$ 0.013	$ 447	$ 133,598
2	2%	35	95.8%	17,200	2	0.013	447	14,858
3	2%	42	95.3%	17,200	2	0.013	447	18,082
4	0%	5	94.3%	17,200	2	0.013	447	2,076
5	34%	607	95.6%	17,200	2	0.013	447	259,528
6	5%	82	98.7%	17,200	2	0.013	447	36,187
7	4%	74	99.5%	17,200	2	0.013	447	32,959
8	0%	-	97.0%	17,200	2	0.013	447	-
9	0%	-	99.5%	17,200	2	0.013	447	-
10	0%	6	95.8%	17,200	2	0.013	447	2,409
11	0%	0	99.7%	17,200	2	0.013	447	104
12	35%	630	0.0%	17,200	2	0.013	447	-
13	0%	4	99.6%	17,200	2	0.013	447	1,878
Total	100%	1,805					**Exchange**	**$ 501,679**
							Annual maintenance	**$ 503,497**
							Total cost	**$ 1,005,176**

POSTPANAMAX Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	906	906	0	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	430	430	0	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number POSTPMAX 1999	78	78	0	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	100%			*Source: NVMC data*
Number in nonEEZ tracks	78			
Estimated annual exchanges		413		*Arrivals in track x probability of exchange in track*

Track	**Percent arrivals in track**	**Arrivals in track**	**Probability of exchange in track**	**Total ballast capacity (m^3)**	**Volumes per ballast exchange**	**Cost per m^3 exchanged**	**Cost per exchange**	**Total cost**
1	0%	-	93.4%	19,100	2	$ 0.013	$ 497	$ -
2	0%	-	95.8%	19,100	2	0.013	497	-
3	0%	-	95.3%	19,100	2	0.013	497	-
4	0%	-	94.3%	19,100	2	0.013	497	-
5	76%	329	95.6%	19,100	2	0.013	497	155,941
6	23%	100	98.7%	19,100	2	0.013	497	48,910
7	0%	-	99.5%	19,100	2	0.013	497	-
8	0%	-	97.0%	19,100	2	0.013	497	-
9	0%	-	99.5%	19,100	2	0.013	497	-
10	0%	-	95.8%	19,100	2	0.013	497	-
11	0%	-	99.7%	19,100	2	0.013	497	-
12	0%	2	0.0%	19,100	2	0.013	497	-
13	0%	-	99.6%	19,100	2	0.013	497	-
Total	100%	430					**Exchange**	**$ 204,852**
							Annual maintenance	**$ 156,000**
							Total cost	**$ 360,852**

POSTPANAMAX Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Number Arrivals	1,396	1,396	0	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	609	609	0	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number POSTPMAX 2000	83	83	0	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	100%			*Source: NVMC data*
Number in nonEEZ tracks	83			

Estimated annual exchanges 584 *Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	0%	-	93.4%	19,100	2	$ 0.013	$ 497	$ -
2	0%	-	95.8%	19,100	2	0.013	497	-
3	0%	-	95.3%	19,100	2	0.013	497	-
4	0%	-	94.3%	19,100	2	0.013	497	-
5	76%	465	95.6%	19,100	2	0.013	497	220,857
6	23%	141	98.7%	19,100	2	0.013	497	69,271
7	0%	-	99.5%	19,100	2	0.013	497	-
8	0%	-	97.0%	19,100	2	0.013	497	-
9	0%	-	99.5%	19,100	2	0.013	497	-
10	0%	-	95.8%	19,100	2	0.013	497	-
11	0%	-	99.7%	19,100	2	0.013	497	-
12	0%	2	0.0%	19,100	2	0.013	497	-
13	0%	-	99.6%	19,100	2	0.013	497	-
Total	100%	609					**Exchange**	**$ 290,127**
							Annual maintenance	**$ 166,000**
							Total cost	**$ 456,127**

PASS Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	3,673	3,649	24	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	599	599	0	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number Pass 1999	122	118	4	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	36%			*Source: NVMC data*
Number in nonEEZ tracks	45			
Estimated annual exchanges		39		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	1%	3	93.4%	2,600	2	$ 0.013	$ 68	$ 216
2	0%	0	95.8%	2,600	2	0.013	68	27
3	1%	4	95.3%	2,600	2	0.013	68	241
4	0%	0	94.3%	2,600	2	0.013	68	13
5	3%	17	95.6%	2,600	2	0.013	68	1,112
6	0%	0	98.7%	2,600	2	0.013	68	21
7	0%	-	99.5%	2,600	2	0.013	68	-
8	0%	-	97.0%	2,600	2	0.013	68	-
9	0%	3	99.5%	2,600	2	0.013	68	181
10	1%	3	95.8%	2,600	2	0.013	68	215
11	0%	-	99.7%	2,600	2	0.013	68	-
12	93%	559	0.0%	2,600	2	0.013	68	-
13	1%	9	99.6%	2,600	2	0.013	68	586
Total	100%	599					**Exchange**	**$ 2,612**
							Annual maintenance	**$ 66,788**
							Total cost	**$ 69,400**

PASS Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Number Arrivals	4,045	4,002	43	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	638	638	0	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number PASS 2000	129	126	3	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	36%			*Source: NVMC data*
Number in nonEEZ tracks	47			

Estimated annual exchanges		41		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	1%	4	93.4%	2,600	2	$ 0.013	$ 68	$ 230
2	0%	0	95.8%	2,600	2	0.013	68	29
3	1%	4	95.3%	2,600	2	0.013	68	256
4	0%	0	94.3%	2,600	2	0.013	68	14
5	3%	18	95.6%	2,600	2	0.013	68	1,184
6	0%	0	98.7%	2,600	2	0.013	68	22
7	0%	-	99.5%	2,600	2	0.013	68	-
8	0%	-	97.0%	2,600	2	0.013	68	-
9	0%	3	99.5%	2,600	2	0.013	68	193
10	1%	4	95.8%	2,600	2	0.013	68	229
11	0%	-	99.7%	2,600	2	0.013	68	-
12	93%	595	0.0%	2,600	2	0.013	68	-
13	1%	9	99.6%	2,600	2	0.013	68	624
Total	100%	638					**Exchange**	**$ 2,782**
							Annual maintenance	**$ 70,620**
							Total cost	**$ 73,402**

GENCARG Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	10,833	10,721	112	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	5,907	5,831	76	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number GENCARG 1999	1,485	1,473	12	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	66%			*Source: NVMC data*
Number in nonEEZ tracks	984			
Estimated annual exchanges		1,923		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	7%	413	93.4%	4,500	2	$ 0.013	$ 117	$ 45,134
2	1%	85	95.8%	4,500	2	0.013	117	9,546
3	5%	299	95.3%	4,500	2	0.013	117	33,341
4	3%	154	94.3%	4,500	2	0.013	117	16,956
5	6%	357	95.6%	4,500	2	0.013	117	39,950
6	2%	114	98.7%	4,500	2	0.013	117	13,109
7	5%	274	99.5%	4,500	2	0.013	117	31,893
8	3%	174	97.0%	4,500	2	0.013	117	19,778
9	0%	6	99.5%	4,500	2	0.013	117	648
10	1%	46	95.8%	4,500	2	0.013	117	5,178
11	0%	1	99.7%	4,500	2	0.013	117	130
12	66%	3,904	0.0%	4,500	2	0.013	117	-
13	1%	80	99.6%	4,500	2	0.013	117	9,336
Total	100%	5,907					**Exchange**	**$ 224,999**
							Annual maintenance	**$ 1,968,851**
							Total cost	**$ 2,193,850**

GENCARG Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Number Arrivals	10,311	10,191	120	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	5,951	5,864	87	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number GENGARG 2000	1,418	1,405	13	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	66%			*Source: NVMC data*
Number in nonEEZ tracks	940			
Estimated annual exchanges		1,937		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	7%	416	93.4%	4,500	2	$ 0.013	$ 117	$ 45,470
2	1%	86	95.8%	4,500	2	0.013	117	9,617
3	5%	301	95.3%	4,500	2	0.013	117	33,589
4	3%	155	94.3%	4,500	2	0.013	117	17,083
5	6%	360	95.6%	4,500	2	0.013	117	40,248
6	2%	114	98.7%	4,500	2	0.013	117	13,206
7	5%	276	99.5%	4,500	2	0.013	117	32,130
8	3%	176	97.0%	4,500	2	0.013	117	19,925
9	0%	6	99.5%	4,500	2	0.013	117	653
10	1%	47	95.8%	4,500	2	0.013	117	5,217
11	0%	1	99.7%	4,500	2	0.013	117	131
12	66%	3,933	0.0%	4,500	2	0.013	117	-
13	1%	81	99.6%	4,500	2	0.013	117	9,406
Total	100%	5,951					**Exchange**	**$ 226,675**
							Annual maintenance	**$ 1,880,021**
							Total cost	**$ 2,106,696**

RORO Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	6,167	5,697	470	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	2,894	2,552	342	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number RORO 1999	428	413	15	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	76%			*Source: NVMC data*
Number in nonEEZ tracks	327			
Estimated annual exchanges		746		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	11%	317	57.2%	7,700	2	$ 0.013	$ 200	$ 36,244
2	2%	48	62.2%	7,700	2	0.013	200	5,981
3	1%	41	66.1%	7,700	2	0.013	200	5,389
4	2%	71	70.9%	7,700	2	0.013	200	10,105
5	21%	611	60.8%	7,700	2	0.013	200	74,336
6	1%	24	75.3%	7,700	2	0.013	200	3,619
7	1%	36	82.4%	7,700	2	0.013	200	5,870
8	0%	5	79.9%	7,700	2	0.013	200	754
9	0%	-	74.2%	7,700	2	0.013	200	-
10	0%	0	64.7%	7,700	2	0.013	200	56
11	0%	-	80.1%	7,700	2	0.013	200	-
12	59%	1,702	0.0%	7,700	2	0.013	200	-
13	1%	40	86.7%	7,700	2	0.013	200	6,923
Total	100%	2,894					**Exchange**	**$ 149,277**
							Annual maintenance	**$ 816,704**
							Total cost	**$ 965,981**

RORO Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	*Source: Bounce data 2000 (MSMS)*
Number Arrivals	6,594	6,034	560	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	2,523	2,115	408	*Source: Arrival data 2000 (MSMS)*
	Total	Foreign	Domestic	*Source: Bounce data 2000 (MSMS)*
Number RORO 2000	443	427	16	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	76%			
Number in nonEEZ tracks	338			
Estimated annual exchanges		650		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	11%	276	57.2%	7,700	2	$ 0.013	$ 200	$ 31,598
2	2%	42	62.2%	7,700	2	0.013	200	5,215
3	1%	36	66.1%	7,700	2	0.013	200	4,698
4	2%	62	70.9%	7,700	2	0.013	200	8,810
5	21%	532	60.8%	7,700	2	0.013	200	64,807
6	1%	21	75.3%	7,700	2	0.013	200	3,155
7	1%	31	82.4%	7,700	2	0.013	200	5,117
8	0%	4	79.9%	7,700	2	0.013	200	658
9	0%	-	74.2%	7,700	2	0.013	200	-
10	0%	0	64.7%	7,700	2	0.013	200	48
11	0%	-	80.1%	7,700	2	0.013	200	-
12	59%	1,484	0.0%	7,700	2	0.013	200	-
13	1%	35	86.7%	7,700	2	0.013	200	6,035
Total	100%	2,523					**Exchange**	**$ 130,141**
							Annual maintenance	**$ 845,326**
							Total cost	**$ 975,467**

COMB Cost Analysis for 1999

1999 Arrivals	Total	Foreign	Domestic	
Number Arrivals	314	310	4	*Source: Arrival data 1999 (MSMS)*
Number EEZ Arrivals	205	202	3	*Source: Arrival data 1999 (MSMS)*

	Total	Foreign	Domestic	
Number COMB 1999	18	14	4	*Source: Arrival data 1999 (MSMS)*
Percent in nonEEZ tracks	50%			*Source: NVMC data*
Number in nonEEZ tracks	9			

Estimated annual exchanges		9		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	0%	-	93.4%	7,300	2	$ 0.013	$ 190	$ -
2	0%	0	95.8%	7,300	2	0.013	190	72
3	0%	1	95.3%	7,300	2	0.013	190	107
4	0%	-	94.3%	7,300	2	0.013	190	-
5	2%	3	95.6%	7,300	2	0.013	190	573
6	0%	-	98.7%	7,300	2	0.013	190	-
7	0%	0	99.5%	7,300	2	0.013	190	37
8	0%	0	97.0%	7,300	2	0.013	190	36
9	0%	-	99.5%	7,300	2	0.013	190	-
10	0%	-	95.8%	7,300	2	0.013	190	-
11	0%	-	99.7%	7,300	2	0.013	190	-
12	96%	196	0.0%	7,300	2	0.013	190	-
13	2%	4	99.6%	7,300	2	0.013	190	821
Total	100%	205					**Exchange**	**$ 1,647**
							Annual maintenance	**$ 18,000**
							Total cost	**$ 19,647**

COMB Cost Analysis for 2000

2000 Arrivals	Total	Foreign	Domestic	
Number Arrivals	218	211	7	*Source: Arrival data 2000 (MSMS)*
Number EEZ Arrivals	84	78	6	*Source: Arrival data 2000 (MSMS)*

	Total	Foreign	Domestic	
Number COMB 2000	24	18	6	*Source: Arrival data 2000 (MSMS)*
Percent in nonEEZ tracks	50%			*Source: NVMC data*
Number in nonEEZ tracks	12			
Estimated annual exchanges		4		*Arrivals in track x probability of exchange in track*

Track	Percent arrivals in track	Arrivals in track	Probability of exchange in track	Total ballast capacity (m^3)	Volumes per ballast exchange	Cost per m^3 exchanged	Cost per exchange	Total cost
1	0%	-	93.4%	7,300	2	$ 0.013	$ 190	$ -
2	0%	0	95.8%	7,300	2	0.013	190	29
3	0%	0	95.3%	7,300	2	0.013	190	44
4	0%	-	94.3%	7,300	2	0.013	190	-
5	2%	1	95.6%	7,300	2	0.013	190	235
6	0%	-	98.7%	7,300	2	0.013	190	-
7	0%	0	99.5%	7,300	2	0.013	190	15
8	0%	0	97.0%	7,300	2	0.013	190	15
9	0%	-	99.5%	7,300	2	0.013	190	-
10	0%	-	95.8%	7,300	2	0.013	190	-
11	0%	-	99.7%	7,300	2	0.013	190	-
12	96%	80	0.0%	7,300	2	0.013	190	-
13	2%	2	99.6%	7,300	2	0.013	190	336
Total	100%	84					**Exchange**	**$ 675**
							Annual maintenance	**$ 24,000**
							Total cost	**$ 24,675**

Appendix D

Calculations of Benefit

Appendix D: Calculations of Benefit

The average annual benefit is calculated using the same vessel arrival data collected for the Chapter 2 cost calculations. Table D-1 provides a summary of the following data that was used to calculate the benefit in Chapter 3.

Table D-1

Summary of Data 1999–2000 Baseline and Post Rule

1999 Baseline	
Total arrivals	33,959
Arrivals with inoculation	32,435
Percent arrivals with inoculation, baseline	96%
1999 Post-rule	
Total arrivals	33,959
Arrivals with inoculation	24,067
Percent arrivals with inoculation, post-rule	71%
Percent arrivals with inoculation, baseline	96%
Net reduction in arrivals with inoculation	**25%**
2000 Baseline	
Total arrivals	35,423
Arrivals with inoculation	35,045
Percent arrivals with inoculation, baseline	99%
2000 Post-rule	
Total arrivals	35,423
Arrivals with inoculation	25,121
Percent arrivals with inoculation, post-rule	71%
Percent arrivals with inoculation, baseline	99%
Net reduction in arrivals with inoculation	**28%**

1999 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
BULK1	1	5%	70%	97%	221	213
BULK1	2	5%	70%	97%	157	152
BULK1	3	5%	70%	97%	276	267
BULK1	4	5%	70%	97%	201	194
BULK1	5	25%	70%	83%	860	709
BULK1	6	25%	70%	83%	188	155
BULK1	7	5%	70%	97%	199	192
BULK1	8	5%	70%	97%	213	206
BULK1	9	5%	70%	97%	1	1
BULK1	10	5%	70%	97%	70	67
BULK1	11	25%	70%	83%	1	1
BULK1	12	0%	70%	100%	2,096	2,096
BULK1	13	5%	70%	97%	28	27
BULK2	1	5%	70%	97%	221	213
BULK2	2	5%	70%	97%	157	152
BULK2	3	5%	70%	97%	276	267
BULK2	4	5%	70%	97%	201	194
BULK2	5	25%	70%	83%	860	709
BULK2	6	25%	70%	83%	188	155
BULK2	7	5%	70%	97%	199	192
BULK2	8	5%	70%	97%	213	206
BULK2	9	5%	70%	97%	1	1
BULK2	10	5%	70%	97%	70	67
BULK2	11	25%	70%	83%	1	1
BULK2	12	0%	70%	100%	2,096	2,096
BULK2	13	5%	70%	97%	28	27
BULK3	1	5%	70%	97%	82	79
BULK3	2	5%	70%	97%	6	5
BULK3	3	5%	70%	97%	46	45
BULK3	4	5%	70%	97%	18	18
BULK3	5	25%	70%	83%	16	13
BULK3	6	25%	70%	83%	3	2
BULK3	7	5%	70%	97%	5	4

1999 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
BULK3	8	5%	70%	97%	128	123
BULK3	9	5%	70%	97%	-	-
BULK3	10	5%	70%	97%	-	-
BULK3	11	25%	70%	83%	-	-
BULK3	12	0%	70%	100%	150	150
BULK3	13	5%	70%	97%	-	-
TANK1	1	5%	70%	97%	13	12
TANK1	2	5%	70%	97%	12	12
TANK1	3	5%	70%	97%	11	11
TANK1	4	5%	70%	97%	14	13
TANK1	5	25%	70%	83%	5	4
TANK1	6	25%	70%	83%	31	26
TANK1	7	5%	70%	97%	79	76
TANK1	8	5%	70%	97%	7	7
TANK1	9	5%	70%	97%	-	-
TANK1	10	5%	70%	97%	1	1
TANK1	11	25%	70%	83%	-	-
TANK1	12	0%	70%	100%	301	301
TANK1	13	5%	70%	97%	26	25
TANK2	1	5%	70%	97%	168	162
TANK2	2	5%	70%	97%	33	32
TANK2	3	5%	70%	97%	189	183
TANK2	4	5%	70%	97%	84	81
TANK2	5	25%	70%	83%	30	25
TANK2	6	25%	70%	83%	71	58
TANK2	7	5%	70%	97%	158	152
TANK2	8	5%	70%	97%	104	100
TANK2	9	5%	70%	97%	1	1
TANK2	10	5%	70%	97%	18	17
TANK2	11	25%	70%	83%	-	-
TANK2	12	0%	70%	100%	2,943	2,943
TANK2	13	5%	70%	97%	35	34
TANK3	1	5%	70%	97%	64	62

1999 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
TANK3	2	5%	70%	97%	3	3
TANK3	3	5%	70%	97%	61	59
TANK3	4	5%	70%	97%	11	11
TANK3	5	25%	70%	83%	19	16
TANK3	6	25%	70%	83%	21	18
TANK3	7	5%	70%	97%	4	4
TANK3	8	5%	70%	97%	217	210
TANK3	9	5%	70%	97%	-	-
TANK3	10	5%	70%	97%	2	2
TANK3	11	25%	70%	83%	4	3
TANK3	12	0%	70%	100%	293	293
TANK3	13	5%	70%	97%	2	2
TANK4	1	5%	70%	97%	3	3
TANK4	2	5%	70%	97%	-	-
TANK4	3	5%	70%	97%	32	31
TANK4	4	5%	70%	97%	157	151
TANK4	5	25%	70%	83%	4	3
TANK4	6	25%	70%	83%	9	8
TANK4	7	5%	70%	97%	1	1
TANK4	8	5%	70%	97%	78	75
TANK4	9	5%	70%	97%	-	-
TANK4	10	5%	70%	97%	9	9
TANK4	11	25%	70%	83%	9	7
TANK4	12	0%	70%	100%	22	22
TANK4	13	5%	70%	97%	-	-
TANK5	1	5%	70%	97%	-	-
TANK5	2	5%	70%	97%	-	-
TANK5	3	5%	70%	97%	-	-
TANK5	4	5%	70%	97%	47	45
TANK5	5	25%	70%	83%	-	-
TANK5	6	25%	70%	83%	-	-
TANK5	7	5%	70%	97%	-	-
TANK5	8	5%	70%	97%	11	11

1999 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
TANK5	9	5%	70%	97%	-	-
TANK5	10	5%	70%	97%	-	-
TANK5	11	25%	70%	83%	3	3
TANK5	12	0%	70%	100%	1	1
TANK5	13	5%	70%	97%	-	-
CHEM	1	5%	90%	96%	148	142
CHEM	2	5%	90%	96%	48	45
CHEM	3	5%	90%	96%	181	173
CHEM	4	5%	90%	96%	57	54
CHEM	5	25%	90%	78%	115	89
CHEM	6	25%	90%	78%	56	44
CHEM	7	5%	90%	96%	104	100
CHEM	8	5%	90%	96%	77	73
CHEM	9	5%	90%	96%	1	1
CHEM	10	5%	90%	96%	2	2
CHEM	11	25%	90%	78%	5	4
CHEM	12	0%	90%	100%	1,331	1,331
CHEM	13	5%	90%	96%	23	22
GAS	1	5%	70%	97%	16	15
GAS	2	5%	70%	97%	9	9
GAS	3	5%	70%	97%	61	59
GAS	4	5%	70%	97%	30	29
GAS	5	25%	70%	83%	14	11
GAS	6	25%	70%	83%	9	7
GAS	7	5%	70%	97%	6	5
GAS	8	5%	70%	97%	21	20
GAS	9	5%	70%	97%	3	2
GAS	10	5%	70%	97%	27	26
GAS	11	25%	70%	83%	1	1
GAS	12	0%	70%	100%	476	476
GAS	13	5%	70%	97%	4	4
FEEDER	1	5%	90%	96%	5	5
FEEDER	2	5%	90%	96%	-	-

1999 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
FEEDER	3	5%	90%	96%	-	-
FEEDER	4	5%	90%	96%	-	-
FEEDER	5	25%	90%	78%	3	2
FEEDER	6	25%	90%	78%	-	-
FEEDER	7	5%	90%	96%	4	3
FEEDER	8	5%	90%	96%	-	-
FEEDER	9	5%	90%	96%	1	1
FEEDER	10	5%	90%	96%	-	-
FEEDER	11	25%	90%	78%	-	-
FEEDER	12	0%	90%	100%	97	97
FEEDER	13	5%	90%	96%	48	46
FEEDERMAX	1	5%	90%	96%	9	8
FEEDERMAX	2	5%	90%	96%	1	1
FEEDERMAX	3	5%	90%	96%	9	8
FEEDERMAX	4	5%	90%	96%	-	-
FEEDERMAX	5	25%	90%	78%	6	5
FEEDERMAX	6	25%	90%	78%	17	13
FEEDERMAX	7	5%	90%	96%	37	35
FEEDERMAX	8	5%	90%	96%	-	-
FEEDERMAX	9	5%	90%	96%	-	-
FEEDERMAX	10	5%	90%	96%	-	-
FEEDERMAX	11	25%	90%	78%	-	-
FEEDERMAX	12	0%	90%	100%	480	480
FEEDERMAX	13	5%	90%	96%	21	20
HANDY	1	5%	90%	96%	301	287
HANDY	2	5%	90%	96%	65	62
HANDY	3	5%	90%	96%	93	89
HANDY	4	5%	90%	96%	36	34
HANDY	5	25%	90%	78%	242	188
HANDY	6	25%	90%	78%	147	114
HANDY	7	5%	90%	96%	33	32
HANDY	8	5%	90%	96%	54	51
HANDY	9	5%	90%	96%	-	-

1999 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
HANDY	10	5%	90%	96%	-	-
HANDY	11	25%	90%	78%	-	-
HANDY	12	0%	90%	100%	844	844
HANDY	13	5%	90%	96%	33	31
SUBPANAMAX	1	5%	90%	96%	323	308
SUBPANAMAX	2	5%	90%	96%	31	30
SUBPANAMAX	3	5%	90%	96%	49	47
SUBPANAMAX	4	5%	90%	96%	5	5
SUBPANAMAX	5	25%	90%	78%	242	188
SUBPANAMAX	6	25%	90%	78%	42	33
SUBPANAMAX	7	5%	90%	96%	22	21
SUBPANAMAX	8	5%	90%	96%	40	39
SUBPANAMAX	9	5%	90%	96%	-	-
SUBPANAMAX	10	5%	90%	96%	9	8
SUBPANAMAX	11	25%	90%	78%	-	-
SUBPANAMAX	12	0%	90%	100%	624	624
SUBPANAMAX	13	5%	90%	96%	39	37
PANAMAX	1	5%	90%	96%	388	371
PANAMAX	2	5%	90%	96%	42	40
PANAMAX	3	5%	90%	96%	52	49
PANAMAX	4	5%	90%	96%	6	6
PANAMAX	5	25%	90%	78%	738	572
PANAMAX	6	25%	90%	78%	100	77
PANAMAX	7	5%	90%	96%	90	86
PANAMAX	8	5%	90%	96%	-	-
PANAMAX	9	5%	90%	96%	-	-
PANAMAX	10	5%	90%	96%	7	7
PANAMAX	11	25%	90%	78%	0	0
PANAMAX	12	0%	90%	100%	765	765
PANAMAX	13	5%	90%	96%	5	5
POSTPANAMAX	1	5%	90%	96%	-	-
POSTPANAMAX	2	5%	90%	96%	-	-
POSTPANAMAX	3	5%	90%	96%	-	-

1999 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
POSTPANAMAX	4	5%	90%	96%	-	-
POSTPANAMAX	5	25%	90%	78%	329	255
POSTPANAMAX	6	25%	90%	78%	100	77
POSTPANAMAX	7	5%	90%	96%	-	-
POSTPANAMAX	8	5%	90%	96%	-	-
POSTPANAMAX	9	5%	90%	96%	-	-
POSTPANAMAX	10	5%	90%	96%	-	-
POSTPANAMAX	11	25%	90%	78%	-	-
POSTPANAMAX	12	0%	90%	100%	2	2
POSTPANAMAX	13	5%	90%	96%	-	-
PASS	1	5%	90%	96%	3	3
PASS	2	5%	90%	96%	0	0
PASS	3	5%	90%	96%	4	4
PASS	4	5%	90%	96%	0	0
PASS	5	25%	90%	78%	17	13
PASS	6	25%	90%	78%	0	0
PASS	7	5%	90%	96%	-	-
PASS	8	5%	90%	96%	-	-
PASS	9	5%	90%	96%	3	3
PASS	10	5%	90%	96%	3	3
PASS	11	25%	90%	78%	-	-
PASS	12	0%	90%	100%	559	559
PASS	13	5%	90%	96%	9	8
GENCARG	1	5%	90%	96%	413	394
GENCARG	2	5%	90%	96%	85	81
GENCARG	3	5%	90%	96%	299	285
GENCARG	4	5%	90%	96%	154	147
GENCARG	5	25%	90%	78%	357	277
GENCARG	6	25%	90%	78%	114	88
GENCARG	7	5%	90%	96%	274	262
GENCARG	8	5%	90%	96%	174	166
GENCARG	9	5%	90%	96%	6	5
GENCARG	10	5%	90%	96%	46	44

1999 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
GENCARG	11	25%	90%	78%	1	1
GENCARG	12	0%	90%	100%	3,904	3,904
GENCARG	13	5%	90%	96%	80	77
RORO	1	5%	90%	96%	317	302
RORO	2	5%	90%	96%	48	46
RORO	3	5%	90%	96%	41	39
RORO	4	5%	90%	96%	71	68
RORO	5	25%	90%	78%	611	473
RORO	6	25%	90%	78%	24	19
RORO	7	5%	90%	96%	36	34
RORO	8	5%	90%	96%	5	5
RORO	9	5%	90%	96%	-	-
RORO	10	5%	90%	96%	0	0
RORO	11	25%	90%	78%	-	-
RORO	12	0%	90%	100%	1,702	1,702
RORO	13	5%	90%	96%	40	38
COMB	1	5%	90%	96%	-	-
COMB	2	5%	90%	96%	0	0
COMB	3	5%	90%	96%	1	1
COMB	4	5%	90%	96%	-	-
COMB	5	25%	90%	78%	3	2
COMB	6	25%	90%	78%	-	-
COMB	7	5%	90%	96%	0	0
COMB	8	5%	90%	96%	0	0
COMB	9	5%	90%	96%	-	-
COMB	10	5%	90%	96%	-	-
COMB	11	25%	90%	78%	-	-
COMB	12	0%	90%	100%	196	196
COMB	13	5%	90%	96%	4	4
Totals					33,959	32,435

1999 Post Rule

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
BULK1	1	57%	70%	60%	221	132
BULK1	2	62%	70%	56%	157	89
BULK1	3	66%	70%	54%	276	148
BULK1	4	71%	70%	50%	201	101
BULK1	5	61%	70%	57%	860	494
BULK1	6	75%	70%	47%	188	89
BULK1	7	82%	70%	42%	199	84
BULK1	8	80%	70%	44%	213	94
BULK1	9	74%	70%	48%	1	0
BULK1	10	65%	70%	55%	70	38
BULK1	11	80%	70%	44%	1	1
BULK1	12	0%	70%	100%	2,096	2,096
BULK1	13	87%	70%	39%	28	11
BULK2	1	57%	70%	60%	221	132
BULK2	2	62%	70%	56%	157	89
BULK2	3	66%	70%	54%	276	148
BULK2	4	71%	70%	50%	201	101
BULK2	5	61%	70%	57%	860	494
BULK2	6	75%	70%	47%	188	89
BULK2	7	82%	70%	42%	199	84
BULK2	8	80%	70%	44%	213	94
BULK2	9	74%	70%	48%	1	0
BULK2	10	65%	70%	55%	70	38
BULK2	11	80%	70%	44%	1	1
BULK2	12	0%	70%	100%	2,096	2,096
BULK2	13	87%	70%	39%	28	11
BULK3	1	57%	70%	60%	82	49
BULK3	2	62%	70%	56%	6	3
BULK3	3	66%	70%	54%	46	25
BULK3	4	71%	70%	50%	18	9
BULK3	5	61%	70%	57%	16	9
BULK3	6	75%	70%	47%	3	1
BULK3	7	82%	70%	42%	5	2

1999 Post Rule

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
BULK3	8	80%	70%	44%	128	56
BULK3	9	74%	70%	48%	-	-
BULK3	10	65%	70%	55%	-	-
BULK3	11	80%	70%	44%	-	-
BULK3	12	0%	70%	100%	150	150
BULK3	13	87%	70%	39%	-	-
TANK1	1	57%	70%	60%	13	8
TANK1	2	62%	70%	56%	12	7
TANK1	3	66%	70%	54%	11	6
TANK1	4	71%	70%	50%	14	7
TANK1	5	61%	70%	57%	5	3
TANK1	6	75%	70%	47%	31	15
TANK1	7	82%	70%	42%	79	33
TANK1	8	80%	70%	44%	7	3
TANK1	9	74%	70%	48%	-	-
TANK1	10	65%	70%	55%	1	0
TANK1	11	80%	70%	44%	-	-
TANK1	12	0%	70%	100%	301	301
TANK1	13	87%	70%	39%	26	10
TANK2	1	57%	70%	60%	168	101
TANK2	2	62%	70%	56%	33	18
TANK2	3	66%	70%	54%	189	102
TANK2	4	71%	70%	50%	84	42
TANK2	5	61%	70%	57%	30	17
TANK2	6	75%	70%	47%	71	33
TANK2	7	82%	70%	42%	158	67
TANK2	8	80%	70%	44%	104	46
TANK2	9	74%	70%	48%	1	1
TANK2	10	65%	70%	55%	18	10
TANK2	11	80%	70%	44%	-	-
TANK2	12	0%	70%	100%	2,943	2,943
TANK2	13	87%	70%	39%	35	14
TANK3	1	57%	70%	60%	64	38

1999 Post Rule

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
TANK3	2	62%	70%	56%	3	2
TANK3	3	66%	70%	54%	61	33
TANK3	4	71%	70%	50%	11	6
TANK3	5	61%	70%	57%	19	11
TANK3	6	75%	70%	47%	21	10
TANK3	7	82%	70%	42%	4	2
TANK3	8	80%	70%	44%	217	96
TANK3	9	74%	70%	48%	-	-
TANK3	10	65%	70%	55%	2	1
TANK3	11	80%	70%	44%	4	2
TANK3	12	0%	70%	100%	293	293
TANK3	13	87%	70%	39%	2	1
TANK4	1	57%	70%	60%	3	2
TANK4	2	62%	70%	56%	-	-
TANK4	3	66%	70%	54%	32	17
TANK4	4	71%	70%	50%	157	79
TANK4	5	61%	70%	57%	4	2
TANK4	6	75%	70%	47%	9	4
TANK4	7	82%	70%	42%	1	0
TANK4	8	80%	70%	44%	78	34
TANK4	9	74%	70%	48%	-	-
TANK4	10	65%	70%	55%	9	5
TANK4	11	80%	70%	44%	9	4
TANK4	12	0%	70%	100%	22	22
TANK4	13	87%	70%	39%	-	-
TANK5	1	57%	70%	60%	-	-
TANK5	2	62%	70%	56%	-	-
TANK5	3	66%	70%	54%	-	-
TANK5	4	71%	70%	50%	47	24
TANK5	5	61%	70%	57%	-	-
TANK5	6	75%	70%	47%	-	-
TANK5	7	82%	70%	42%	-	-
TANK5	8	80%	70%	44%	11	5

1999 Post Rule

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
TANK5	9	74%	70%	48%	-	-
TANK5	10	65%	70%	55%	-	-
TANK5	11	80%	70%	44%	3	2
TANK5	12	0%	70%	100%	1	1
TANK5	13	87%	70%	39%	-	-
CHEM	1	93%	90%	16%	148	24
CHEM	2	96%	90%	14%	48	7
CHEM	3	95%	90%	14%	181	26
CHEM	4	94%	90%	15%	57	9
CHEM	5	96%	90%	14%	115	16
CHEM	6	99%	90%	11%	56	6
CHEM	7	100%	90%	10%	104	11
CHEM	8	97%	90%	13%	77	10
CHEM	9	100%	90%	10%	1	0
CHEM	10	96%	90%	14%	2	0
CHEM	11	100%	90%	10%	5	1
CHEM	12	0%	90%	100%	1,331	1,331
CHEM	13	100%	90%	10%	23	2
GAS	1	57%	70%	60%	16	9
GAS	2	62%	70%	56%	9	5
GAS	3	66%	70%	54%	61	33
GAS	4	71%	70%	50%	30	15
GAS	5	61%	70%	57%	14	8
GAS	6	75%	70%	47%	9	4
GAS	7	82%	70%	42%	6	2
GAS	8	80%	70%	44%	21	9
GAS	9	74%	70%	48%	3	1
GAS	10	65%	70%	55%	27	15
GAS	11	80%	70%	44%	1	0
GAS	12	0%	70%	100%	476	476
GAS	13	87%	70%	39%	4	1
FEEDER	1	93%	90%	16%	5	1
FEEDER	2	96%	90%	14%	-	-

1999 Post Rule

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
FEEDER	3	95%	90%	14%	-	-
FEEDER	4	94%	90%	15%	-	-
FEEDER	5	96%	90%	14%	3	0
FEEDER	6	99%	90%	11%	-	-
FEEDER	7	100%	90%	10%	4	0
FEEDER	8	97%	90%	13%	-	-
FEEDER	9	100%	90%	10%	1	0
FEEDER	10	96%	90%	14%	-	-
FEEDER	11	100%	90%	10%	-	-
FEEDER	12	0%	90%	100%	97	97
FEEDER	13	100%	90%	10%	48	5
FEEDERMAX	1	93%	90%	16%	9	1
FEEDERMAX	2	96%	90%	14%	1	0
FEEDERMAX	3	95%	90%	14%	9	1
FEEDERMAX	4	94%	90%	15%	-	-
FEEDERMAX	5	96%	90%	14%	6	1
FEEDERMAX	6	99%	90%	11%	17	2
FEEDERMAX	7	100%	90%	10%	37	4
FEEDERMAX	8	97%	90%	13%	-	-
FEEDERMAX	9	100%	90%	10%	-	-
FEEDERMAX	10	96%	90%	14%	-	-
FEEDERMAX	11	100%	90%	10%	-	-
FEEDERMAX	12	0%	90%	100%	480	480
FEEDERMAX	13	100%	90%	10%	21	2
HANDY	1	93%	90%	16%	301	48
HANDY	2	96%	90%	14%	65	9
HANDY	3	95%	90%	14%	93	13
HANDY	4	94%	90%	15%	36	5
HANDY	5	96%	90%	14%	242	34
HANDY	6	99%	90%	11%	147	16
HANDY	7	100%	90%	10%	33	3
HANDY	8	97%	90%	13%	54	7
HANDY	9	100%	90%	10%	-	-

1999 Post Rule

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
HANDY	10	96%	90%	14%	-	-
HANDY	11	100%	90%	10%	-	-
HANDY	12	0%	90%	100%	844	844
HANDY	13	100%	90%	10%	33	3
SUBPANAMAX	1	93%	90%	16%	323	51
SUBPANAMAX	2	96%	90%	14%	31	4
SUBPANAMAX	3	95%	90%	14%	49	7
SUBPANAMAX	4	94%	90%	15%	5	1
SUBPANAMAX	5	96%	90%	14%	242	34
SUBPANAMAX	6	99%	90%	11%	42	5
SUBPANAMAX	7	100%	90%	10%	22	2
SUBPANAMAX	8	97%	90%	13%	40	5
SUBPANAMAX	9	100%	90%	10%	-	-
SUBPANAMAX	10	96%	90%	14%	9	1
SUBPANAMAX	11	100%	90%	10%	-	-
SUBPANAMAX	12	0%	90%	100%	624	624
SUBPANAMAX	13	100%	90%	10%	39	4
PANAMAX	1	93%	90%	16%	388	62
PANAMAX	2	96%	90%	14%	42	6
PANAMAX	3	95%	90%	14%	52	7
PANAMAX	4	94%	90%	15%	6	1
PANAMAX	5	96%	90%	14%	738	103
PANAMAX	6	99%	90%	11%	100	11
PANAMAX	7	100%	90%	10%	90	9
PANAMAX	8	97%	90%	13%	-	-
PANAMAX	9	100%	90%	10%	-	-
PANAMAX	10	96%	90%	14%	7	1
PANAMAX	11	100%	90%	10%	0	0
PANAMAX	12	0%	90%	100%	765	765
PANAMAX	13	100%	90%	10%	5	1
POSTPANAMAX	1	93%	90%	16%	-	-
POSTPANAMAX	2	96%	90%	14%	-	-
POSTPANAMAX	3	95%	90%	14%	-	-

1999 Post Rule

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
POSTPANAMAX	4	94%	90%	15%	-	-
POSTPANAMAX	5	96%	90%	14%	329	46
POSTPANAMAX	6	99%	90%	11%	100	11
POSTPANAMAX	7	100%	90%	10%	-	-
POSTPANAMAX	8	97%	90%	13%	-	-
POSTPANAMAX	9	100%	90%	10%	-	-
POSTPANAMAX	10	96%	90%	14%	-	-
POSTPANAMAX	11	100%	90%	10%	-	-
POSTPANAMAX	12	0%	90%	100%	2	2
POSTPANAMAX	13	100%	90%	10%	-	-
PASS	1	93%	90%	16%	3	1
PASS	2	96%	90%	14%	0	0
PASS	3	95%	90%	14%	4	1
PASS	4	94%	90%	15%	0	0
PASS	5	96%	90%	14%	17	2
PASS	6	99%	90%	11%	0	0
PASS	7	100%	90%	10%	-	-
PASS	8	97%	90%	13%	-	-
PASS	9	100%	90%	10%	3	0
PASS	10	96%	90%	14%	3	0
PASS	11	100%	90%	10%	-	-
PASS	12	0%	90%	100%	559	559
PASS	13	100%	90%	10%	9	1
GENCARG	1	93%	90%	16%	413	66
GENCARG	2	96%	90%	14%	85	12
GENCARG	3	95%	90%	14%	299	42
GENCARG	4	94%	90%	15%	154	23
GENCARG	5	96%	90%	14%	357	50
GENCARG	6	99%	90%	11%	114	13
GENCARG	7	100%	90%	10%	274	29
GENCARG	8	97%	90%	13%	174	22
GENCARG	9	100%	90%	10%	6	1
GENCARG	10	96%	90%	14%	46	6

1999 Post Rule

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
GENCARG	11	100%	90%	10%	1	0
GENCARG	12	0%	90%	100%	3,904	3,904
GENCARG	13	100%	90%	10%	80	8
RORO	1	57%	90%	49%	317	154
RORO	2	62%	90%	44%	48	21
RORO	3	66%	90%	41%	41	17
RORO	4	71%	90%	36%	71	26
RORO	5	61%	90%	45%	611	277
RORO	6	75%	90%	32%	24	8
RORO	7	82%	90%	26%	36	9
RORO	8	80%	90%	28%	5	1
RORO	9	74%	90%	33%	-	-
RORO	10	65%	90%	42%	0	0
RORO	11	80%	90%	28%	-	-
RORO	12	0%	90%	100%	1,702	1,702
RORO	13	87%	90%	22%	40	9
COMB	1	93%	90%	16%	-	-
COMB	2	96%	90%	14%	0	0
COMB	3	95%	90%	14%	1	0
COMB	4	94%	90%	15%	-	-
COMB	5	96%	90%	14%	3	0
COMB	6	99%	90%	11%	-	-
COMB	7	100%	90%	10%	0	0
COMB	8	97%	90%	13%	0	0
COMB	9	100%	90%	10%	-	-
COMB	10	96%	90%	14%	-	-
COMB	11	100%	90%	10%	-	-
COMB	12	0%	90%	100%	196	196
COMB	13	100%	90%	10%	4	0
Totals					33,959	24,067

2000 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
BULK1	1	3%	70%	98%	237	232
BULK1	2	3%	70%	98%	169	165
BULK1	3	3%	70%	98%	297	290
BULK1	4	3%	70%	98%	216	211
BULK1	5	3%	70%	98%	923	904
BULK1	6	3%	70%	98%	202	198
BULK1	7	3%	70%	98%	214	210
BULK1	8	3%	70%	98%	229	224
BULK1	9	3%	70%	98%	1	1
BULK1	10	3%	70%	98%	75	73
BULK1	11	3%	70%	98%	1	1
BULK1	12	0%	70%	100%	2,250	2,250
BULK1	13	3%	70%	98%	30	29
BULK2	1	3%	70%	98%	237	232
BULK2	2	3%	70%	98%	169	165
BULK2	3	3%	70%	98%	297	290
BULK2	4	3%	70%	98%	216	211
BULK2	5	3%	70%	98%	923	904
BULK2	6	3%	70%	98%	202	198
BULK2	7	3%	70%	98%	214	210
BULK2	8	3%	70%	98%	229	224
BULK2	9	3%	70%	98%	1	1
BULK2	10	3%	70%	98%	75	73
BULK2	11	3%	70%	98%	1	1
BULK2	12	0%	70%	100%	2,250	2,250
BULK2	13	3%	70%	98%	30	29
BULK3	1	3%	70%	98%	76	75
BULK3	2	3%	70%	98%	5	5
BULK3	3	3%	70%	98%	43	42
BULK3	4	3%	70%	98%	17	17
BULK3	5	3%	70%	98%	15	14
BULK3	6	3%	70%	98%	3	3
BULK3	7	3%	70%	98%	4	4

2000 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
BULK3	8	3%	70%	98%	118	116
BULK3	9	3%	70%	98%	-	-
BULK3	10	3%	70%	98%	-	-
BULK3	11	3%	70%	98%	-	-
BULK3	12	0%	70%	100%	139	139
BULK3	13	3%	70%	98%	-	-
TANK1	1	3%	70%	98%	15	15
TANK1	2	3%	70%	98%	15	14
TANK1	3	3%	70%	98%	13	13
TANK1	4	3%	70%	98%	17	16
TANK1	5	3%	70%	98%	6	6
TANK1	6	3%	70%	98%	37	36
TANK1	7	3%	70%	98%	95	93
TANK1	8	3%	70%	98%	8	8
TANK1	9	3%	70%	98%	-	-
TANK1	10	3%	70%	98%	1	1
TANK1	11	3%	70%	98%	-	-
TANK1	12	0%	70%	100%	362	362
TANK1	13	3%	70%	98%	31	30
TANK2	1	3%	70%	98%	187	183
TANK2	2	3%	70%	98%	36	36
TANK2	3	3%	70%	98%	211	206
TANK2	4	3%	70%	98%	93	91
TANK2	5	3%	70%	98%	34	33
TANK2	6	3%	70%	98%	79	77
TANK2	7	3%	70%	98%	176	172
TANK2	8	3%	70%	98%	116	113
TANK2	9	3%	70%	98%	1	1
TANK2	10	3%	70%	98%	20	19
TANK2	11	3%	70%	98%	-	-
TANK2	12	0%	70%	100%	3,279	3,279
TANK2	13	3%	70%	98%	39	38
TANK3	1	3%	70%	98%	64	63

2000 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
TANK3	2	3%	70%	98%	3	3
TANK3	3	3%	70%	98%	61	60
TANK3	4	3%	70%	98%	11	11
TANK3	5	3%	70%	98%	19	19
TANK3	6	3%	70%	98%	21	21
TANK3	7	3%	70%	98%	4	4
TANK3	8	3%	70%	98%	217	213
TANK3	9	3%	70%	98%	-	-
TANK3	10	3%	70%	98%	2	2
TANK3	11	3%	70%	98%	4	4
TANK3	12	0%	70%	100%	293	293
TANK3	13	3%	70%	98%	2	2
TANK4	1	3%	70%	98%	3	3
TANK4	2	3%	70%	98%	-	-
TANK4	3	3%	70%	98%	35	34
TANK4	4	3%	70%	98%	168	165
TANK4	5	3%	70%	98%	4	4
TANK4	6	3%	70%	98%	10	10
TANK4	7	3%	70%	98%	1	1
TANK4	8	3%	70%	98%	83	82
TANK4	9	3%	70%	98%	-	-
TANK4	10	3%	70%	98%	10	10
TANK4	11	3%	70%	98%	9	9
TANK4	12	0%	70%	100%	24	24
TANK4	13	3%	70%	98%	-	-
TANK5	1	3%	70%	98%	-	-
TANK5	2	3%	70%	98%	-	-
TANK5	3	3%	70%	98%	-	-
TANK5	4	3%	70%	98%	21	20
TANK5	5	3%	70%	98%	-	-
TANK5	6	3%	70%	98%	-	-
TANK5	7	3%	70%	98%	-	-
TANK5	8	3%	70%	98%	5	5

2000 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
TANK5	9	3%	70%	98%	-	-
TANK5	10	3%	70%	98%	-	-
TANK5	11	3%	70%	98%	2	1
TANK5	12	0%	70%	100%	1	1
TANK5	13	3%	70%	98%	-	-
CHEM	1	3%	90%	97%	190	185
CHEM	2	3%	90%	97%	61	59
CHEM	3	3%	90%	97%	232	226
CHEM	4	3%	90%	97%	73	71
CHEM	5	3%	90%	97%	148	144
CHEM	6	3%	90%	97%	72	70
CHEM	7	3%	90%	97%	133	130
CHEM	8	3%	90%	97%	98	95
CHEM	9	3%	90%	97%	1	1
CHEM	10	3%	90%	97%	2	2
CHEM	11	3%	90%	97%	6	6
CHEM	12	0%	90%	100%	1,702	1,702
CHEM	13	3%	90%	97%	30	29
GAS	1	3%	70%	98%	17	16
GAS	2	3%	70%	98%	10	10
GAS	3	3%	70%	98%	65	64
GAS	4	3%	70%	98%	32	32
GAS	5	3%	70%	98%	15	15
GAS	6	3%	70%	98%	9	9
GAS	7	3%	70%	98%	6	6
GAS	8	3%	70%	98%	22	22
GAS	9	3%	70%	98%	3	3
GAS	10	3%	70%	98%	29	28
GAS	11	3%	70%	98%	1	1
GAS	12	0%	70%	100%	506	506
GAS	13	3%	70%	98%	4	4
FEEDER	1	3%	90%	97%	4	4
FEEDER	2	3%	90%	97%	-	-

2000 Baseline

Vessel Type	Track	Probability of exchange	Effectiveness of exchange	Probability of inoculation	Number of arrivals	Number of arrivals with inoculation
FEEDER	3	3%	90%	97%	-	-
FEEDER	4	3%	90%	97%	-	-
FEEDER	5	3%	90%	97%	2	2
FEEDER	6	3%	90%	97%	-	-
FEEDER	7	3%	90%	97%	3	2
FEEDER	8	3%	90%	97%	-	-
FEEDER	9	3%	90%	97%	1	1
FEEDER	10	3%	90%	97%	-	-
FEEDER	11	3%	90%	97%	-	-
FEEDER	12	0%	90%	100%	67	67
FEEDER	13	3%	90%	97%	33	32
FEEDERMAX	1	3%	90%	97%	10	9
FEEDERMAX	2	3%	90%	97%	1	1
FEEDERMAX	3	3%	90%	97%	10	9
FEEDERMAX	4	3%	90%	97%	-	-
FEEDERMAX	5	3%	90%	97%	7	7
FEEDERMAX	6	3%	90%	97%	18	18
FEEDERMAX	7	3%	90%	97%	40	39
FEEDERMAX	8	3%	90%	97%	-	-
FEEDERMAX	9	3%	90%	97%	-	-
FEEDERMAX	10	3%	90%	97%	-	-
FEEDERMAX	11	3%	90%	97%	-	-
FEEDERMAX	12	0%	90%	100%	523	523
FEEDERMAX	13	3%	90%	97%	23	22
HANDY	1	3%	90%	97%	322	313
HANDY	2	3%	90%	97%	70	68
HANDY	3	3%	90%	97%	100	97
HANDY	4	3%	90%	97%	38	37
HANDY	5	3%	90%	97%	259	252
HANDY	6	3%	90%	97%	157	152
HANDY	7	3%	90%	97%	36	35
HANDY	8	3%	90%	97%	58	56
HANDY	9	3%	90%	97%	-	-

Appendix E

Initial Regulatory Flexibility Act Analysis

Appendix E: Initial Regulatory Flexibility Act Analysis

Company	SIC	NAICS	Revenue	No. of Employees	No. of Vessels	Avg. No. of Exchanges	Vessel Type	Cost of Exchange	Cost of Maintenance	Cost of Reg	Impact on Revenue
Company 1	4213-04	48423013	$1-2.5M	5 to 9	2	28	TANK2	$ 1,229	$ 6,000	$ 40,412	4.0%
Company 2	4213-06	48423016	$500K-1M	1 to 4	2	2	TANK1	250	5,000	5,500	1.1%
Company 3	4449-02	483211105	$10-20M	1 to 4	1	3	COMB	190	2,000	2,570	0.0%
Company 4	4489-03	48721008	$1-2.5M	250-499	1	2	BULK2	1,388	3,000	5,776	0.6%
Company 5	4489-03	48721008	$1-2.5M	10 to 19	7	20	BULK2	1,388	21,000	48,760	4.9%
Company 6	4731-01	48851011	$1-2.5M	10 to 19	1	6	TANK1	250	2,500	4,000	0.4%
Company 7	6021-01	52211002	$2.5-10	10 to 19	1	2	TANK2	1,229	3,000	5,458	0.2%
Company 8	6021-02	52399112	$2.5-5M	10 to 19	2	55	TANK3	2,110	7,000	123,050	4.9%
Company 9			$1-2.5M		1	5	TANK2	1,229	3,000	9,145	0.9%
Company 10	8742-01	54161401	$500K-1M	1 TO 4	2	30	COMB	190	4,000	9,700	1.9%